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IN WHICH

THE PRINCIPLES OF NUMBERS

AND

Natural Philosophy

ARE

CLEARLY AND COPIOUSLY ELUCIDATED,

BY

A Series of Easy, Entertaining, and Interesting

EXPERIMENTS;

AMONG WHICH ARE ALL THOSE COMMONLY PERFORMED WITH

THE CARDS.

BY W. HOOPER, M.D.

THE FOURTH EDITION, CORRECTED.

ILLUSTRATED WITH

Sixty-five Copperplates.

VOL. II.

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DESCRIPTION OF THE PLATES.

IN THE

SECOND VOLUME.

PLATE I. p. 4.

THE electric machine. The two boards *a*, *a*, are equal and parallel: the uppermoſt has a groove, in which one of the pillars is moveable; the other *b*, is fixed. The braſs arm *c* ſupports the axis *d* that is fixed in the globe; *f* is the rubber, ſupported by an axis in the wooden circle *g*; *h* is a ſteel ſpring, regulated by a ſcrew *i*; *k* is the prime conductor, conſiſting of a hollow veſſel of poliſhed copper, and receives its electricity by means of pointed wires *m*, and the arched braſs rod *l*. The globe is turned by the wheel fixed in the moveable frame *e*. The chain *n* connects the rubber with the floor, when poſitive electricity is required.

PLATE II. p. 12.

The ſquare figure *b* repreſents a plated coat of glaſs. *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, *k*, are ſeveral ſorts of jars. On the ſtand *c*, are placed on a glaſs the cork-balls, that ſerve as an electrometer. From the end of the conductor at l, hang the bells and knobs of braſs for the magic dance; *s* is a metal rod for taking ſparks from the conductor.

PLATE III. p. 20.

Fig. 1. The electrometer. A is a light rod that turns on the centre of the ſemicircle B, and has at its extremity a cork-ball C; D is the pillar that ſupports the rod.

Fig. 2. The fulmineous conducter: *a* is an oblong pole, *b* a copper veſſel in form of a funnel, *c* a ſlender rod, terminated with a pointed wire; *d* is a wire that deſcends at a foot diſtance from the building, and is carried into the room where the experiments are to be performed.

Fig. 3. The electric branch and table: *a*, *b*, *c*, *d*, is the table, placed againſt the partition X. The branch ABC is joined at A to the prime conductor in the other room; *e* and *f* are two links that come from two chains which communicate with the two ſides of a jar or battery, and are concealed in the table.

Fig. 4. The apparatus for conducting the electricity from a kite; *a* is the ſtring of the kite, wound upon a reel

b;

b; *c* a copper funnel, from which goes the metal rod *d*, that has a knob; *e* is the ſtaff that ſupports the funnel and reel; *f* is the chain by which the electricity is conducted to the ground: *g h i k* the inſtrument for taking ſparks from the apparatus.

PLATE IV. p. 46.

Fig. 1. Repreſents the row of tin foil for exhibiting the luminous characters.

Fig. 2. The electrical battery, conſiſting of ſixty-four glaſs jars, which are connected by braſs rods, that run through wires in each of them, and the rods are connected by a chain laid over them.

PLATE V. p. 54.

The method of making artificial magnets. Fig. 1. the poker rubbed by the tongs. Fig. 2, 3, and 4, the manner of giving the bars the vertical touch. Fig. 5, the method of giving them the horizontal touch. Fig. 6, the manner of diſpoſing the bars in a caſe.

PLATE VI. p. 58.

Fig. 1. AB and CD are the poles of two magnets, and the dotted lines ſhow the direction of the magnetic effluvia.

Fig. 2 and 3. The magnetic perſpective. In Fig. 3, B is a magnetic needle, placed on an ivory circle C, that reſts on the object glaſs D: A is the eye-glaſs, by which the poſition of the needle is more clearly diſtinguiſhed.

Fig. 4. The magnetic wand. C is a magnetic bar, which is incloſed in the hollow wand AB.

PLATE VII. p. 60.

Fig. 1. The bouquets, one of which is to be placed in the vaſe E, at the bottom of the box ABCD.

Fig. 2. The magnetic dial. A is a circular border that turns quite free on the ſtand B; C a dial of paſteboard, that moves in the circular border; I a magnetic needle, which is the index to the dial; P a pin, that ſhows where the magnetic bar Fig. 3, is placed, under the dial.

Fig. 4. The dial for the magnetic cards, which is to be placed in the circular border of the laſt figure.

PLATE VIII. p. 64.

Fig. 1. M and N the two boxes for the dextrous painter; P is a pivot, on which the circle of paſteboard, Fig. 2. is placed, in the box N; O, P, Q, R, are four boards, on which

which the ſame ſubjects are painted as on the paſteboard circle; V is an artificial magnet concealed in each of the boards.

PLATE IX. p. 66.

Fig. 1. The apparatus for the cylindric oracle. ABCD is the cylinder, in which is concealed in the magnet H, at EF; G is a circle to be placed on the cylinder, and has a touched needle for an index.

Fig. 2. The box in which one of the four ſquare pieces Fig. 3, that have each a magnet in a different direction, is to be placed.

Fig. 4. The dial to be placed over the box, Fig. 2.

PLATE X. p. 68.

Fig. 1. An ewer A, placed on a ſtand BC, in which is a drawer D.

Fig. 2. The inſide of the ewer, in the middle of which is an inverted tin cone; at H is a mirror.

Fig. 3. A paſteboard circle that is placed at QR in the laſt figure. This circle contains a touched needle, and is divided into four parts, in three of which are heads with different dreſſes.

Fig. 4. Four ſquare pieces of wood, each of which contains a magnet in a different poſition, and in three of them are the ſame figures as on the paſteboard.

Fig. 5. The magician's circles. The circle A has a hand that communicates with a movement in the box. The index of the circle B is a touched needle: C the croſs-piece by which the needles are connected.

Fig. 6. The movement contained in the boxes under the two circles, and the croſs piece between them, in the laſt figure.

PLATE XI. p. 74.

Fig 1. The box and dice. CA a hollow pedeſtal, on which is the circle B, marked with the numbers on two dice, and at its centre is a pivot, on which turns a touched needle; M a ſimilar circle on the bottom of the box; DE is a vaſe, in which there are different diviſions H, G, F. In the part IK is placed the piece ST.

Fig. 2. is a box, in which are placed the two caſes Fig. 3 and 4, that have each a magnet at O, and in each of which are placed two flowers; G E O is the ſection of theſe two caſes.

PLATE XII. p. 76.

Fig. 1. ABCD a box that contains ſix different pieces of metal, which have each a magnet in a different poſition.

Fig. 2. The circles that are placed in the end of a perſpective, and have the initials of the different metals.

Fig. 3. The box for the magnetic oracle. A, B, C, the three diviſions of the box: in A and C are ſmall rundlets marked with numbers.

Fig. 4. The magnets to be fixed in eight ſmall tablets, that are to be put in the part B of the laſt figure.

Fig. 5. A circle, with a touched needle for an index, which is to be placed on the part B of Fig. 3. over one of the tablets, in which a magnet is concealed.

Fig. 6. ABCD is the box for the magical cards, in the top of which is an opening of the ſize of a card. At the centre of this box is a pivot, on which is placed a circle that has two cards painted on it, and a touched needle at its center. Between the two figures of the box is the magnetic wand.

PLATE XIII. p. 80.

Fig. 1. The magnetic planetarium. The central circle A has an index that communicates with another circle underneath; and round it are wrote ſeven queſtions. Round the ſeven leſſer circles are wrote words that form anſwers to thoſe queſtions; and within theſe circles are drawn the characters of the five planets, with the earth and moon. On the center of each of theſe circles turns a magnetic needle, and the dotted lines in each of them ſhow the poſition of the magnets in ſeven other circles on the bottom of the box.

Fig. 2. Shows the inſide of the box, and the two indexes at top: by the loweſt is turned the circle, fixed on a pivot at the bottom of the box and the other is placed againſt one of the months inſcribed round the circle. Q and R are two of the needles to be placed on the ſmall circles.

PLATE XIV. p. 83.

Fig. 1 and 2. The magnetical table. ABCD, Fig. 1, the bottom of the table: at A, on the top of the table, is a circle, that ſurrounds a baſon, placed over P, where is the machinery, Fig. 3, which conſiſts of a wheel QR, a barrel X, a ſmall toothed wheel T, and the magnetic bar XY. MO is a magnetic bar, moveable on a pulley, round which goes a ſtring, that is faſtened at one end to the ſpring N, and goes over another pulley at A. OP, at the part of the table,

table next AB, is a magnetic bar, moveable on a pivot at P. The motion of this bar is regulated by the ſpring R. Round the pulley T goes a ſtring, that paſſes over another pulley at S. AB, near the part AR, is the magnetic roller, which is drawn backward and forward by a ſtring that paſſes over the pullies B and A, and is deſcribed in Pl. XVII. Fig. 5.

Fig. 2. AB, the top of the table, on which is placed the baſon: R, F, G, H, the legs, which are hollow, L, L, the croſs pieces, MN the ſtep: theſe are likewiſe all hollow, and communicate with the other ſide of the partition.

Fig. 4 and 5, are two other circles to be placed round the baſon on the table.

PLATE XV. p. 84.

The ſcale to be placed againſt the back of the partition W. in Plate XIV. Fig. 2. C is the pulley over which the ſtring goes; D the weight; and EF the index. The diviſions of this ſcale correſpond to thoſe on the three circles in the laſt plate, Fig. 1, 4 and 5.

PLATE XVI. p. 89.

The apparatus for the ſagacious ſwan. Fig. 1. YX a hollow pedeſtal, on which is placed the baſon A, and round it are ſix vaſes; B is a hollow egg, placed on a ſtand C, that is alſo hollow; MO is the magnet and wheel placed in the pedeſtal. The figures *a* ſhow the poſition of the vaſes.

Fig. 2. The machinery for moving the magnet, which is regulated by one of the etwees Y, and the cylinder F, Fig. 3, placed in the egg B and the ſtand C.

PLATE XVII. p. 94.

Fig. 1. The communicative bell. AB a copper box, E the inſide of the box, F the bell, D a magnet, that is placed on a pivot, and ſtrikes the bell.

Fig. 2. The magnetic balance, the ſcales of which are to be placed over the magnetic table at the part where is the magnet MO.

Fig. 3. The movement of the ſympathetic dials. ABCD the wheels and pinions, under which is the barrel A, F the fly, H the plate to which the movement is fixed, LNM a catch of ſteel that is touched.

Fig. 4. QR is a caſe in which each of the dials is to be placed.

Fig. 5. The magnetic roller, in the twelve circles of which are placed magnets in different poſitions, marked with the letters of the alphabet.

PLATE XVIII. p. 98.

Fig. 1. The magician's box. AB is the baſe of the box, in the top of which is a hole E, about the ſize of a card: in this baſe is placed the circle OP, Fig. 3, that has five cards painted on it; contains a magnet QR, and is moveable on a pivot.

Fig. 2, is the body of the box, which conſiſts of four inclined planes of glaſs; and in a hole at the top is fixed a convex lens V. This box is placed on the magnetic table, by which either of the cards on the circle are brought under the hole.

Fig. 4. The myſtical dial: this dial is divided into ten equal parts, and at its centre is a touched needle, which is regulated by the magnetic table.

Fig. 5. The box for the intelligent fly. At the centre of the box is a pivot, on which is placed a touched needle I., that has at one end of it an enamelled fly: over this needle is placed the paſteboard circle ABCD, on which ten letters are wrote.

PLATE XIX. p. 105.

Fig. 1. The box with the eight tablets, on which are wrote the multifarious verſe, and in each of which is concealed a magnet, in a different direction.

Fig. 2. A board of the ſame ſize of the foregoing box, on which are drawn eight circles that have each the ſame words wrote round them as are on the tablets; and on the center of each of theſe circles is fixed a magnetic needle; this board is to be placed over the box.

Fig. 3. Four plates of glaſs, placed in an inclined poſition over the board, and in its top are two lenſes O, O.

PLATE XX. p. 108.

Fig. 1. The communicative mirror. AB is a hollow pedeſtal, in which is a hole at L, and over that is placed a ſtand, compoſed of four plates of glaſs CD, and on that is fixed a tube E, including another tube F. There is a hole through the tubes, next the top of the ſtand, and againſt it is placed an inclined mirror M, by which the eye at G ſees the paſteboard circle Fig. 2, fixed on a pivot at the bottom of the box.

Fig. 3. A box of the ſame ſize as the pedeſtal juſt deſcribed. In this box is placed one of the three tablets X, Y, Z, that have each a magnet in a different poſition, and over each

each of them is paſted a card of the ſame ſort with thoſe on the circle. When this box is placed in the pedeſtal the needle in the circle conforms to the poſition of the magnet in the tablet.

Fig. 4. The box of dice by reflection. ABCD the box, whoſe top and ſides are of glaſs. IL two hollow cubes. At the end of the box are ſliders that draw up as in Fig. 5, and at M is a ſmall moveable piece that covers a hole. OP and RQ, are two inclined mirrors placed in the box. The bottom of each of the cubes is divided into four equal parts, as in Fig. 8, and under each of them is placed a braſs ſtand, Fig. 6, diſpoſed as in Fig. 7, and on the ſtand is a pivot that holds two needles, one of braſs the other of ſteel that is touched.

PLATE XXI. p. 112.

The common air pump. AA, are two braſs barrels; CC, two piſtons, working in thoſe barrels; B the handle by which they are worked; GG, the pillars that ſupport the frame of the pump wheel, ſcrewed on them by the nuts FF; HH is a braſs pipe called the ſwan's neck, through which the air paſſes, from under the receiver OO, by a ſmall hole K, in the middle of the braſs plate I, to a braſs piece in the box DD, from whence it is pumped out. LLL is a mercurial gage, that communicates with the receiver; N the ſtop-cock, by which the air is re-admitted, when neceſſary.

PLATE XXII. p. 114.

Fig. 1. The animometer. ABCDEFGH is a frame of wood, ſupported by the poſt P; QM a horizontal axis, that moves in the croſs pieces I and L, by means of the four ſails *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*; on this axis is fixed a cone of wood, MNO, by which the weight S is raiſed: IK is a ratchet wheel, whoſe teeth are taken by the click X.

Fig. 2. The circular hygrometer. ABCD is a ſquare board; at the point E a catgut is fixed, that paſſing over ſeveral pullies, marked C, is faſtened at the other end to the ſpring F, which is regulated by the ſcrew I. At H a braſs indented ruler takes the teeth of a pinion K, whoſe axis goes through the board, and on the other ſide carries the index A that points to the diviſions of the circle E.

Fig. 3 and 4. The perpendicular hygrometer. The circles marked C are pullies, over which paſſes a ſtring, that is faſtened at A, and the other end has a weight F. A piece

of braſs is fixed to the ſtring at G, and moves freely in the groove HI; to this braſs piece, on the other ſide of the board is faſtened an index E, Fig. 4, which ſhows the degree of moiſture, by the ſcale LM.

Fig. 5. RS a catgut that is faſtened at S, paſſes over the pully T, and has a weight at V, to the top of which is faſtened an index that points to the ſcale Z.

PLATE XXIII. p. 128.

Fig. 1. The air gun. ECDR the outer barrel; KA the inner barrel; SMNP the ſyringe, by which the air is injected through the valve NP; TL another valve, that is opened by the trigger O, by which the air enters behind the ball at K, and drives it out.

Fig. 2. The lock of this gun.

Fig. 3. The machine for artificial rain and hail. A, A, &c. the boards that have holes through which ſhot paſſes. D the axis on which the wheel turns.

Fig. 4. The magical tree. ABCD the box that contains the copper veſſel FG, into which air is forced by the ſyringe MN, Fig. 5. At I is a cock, that lets the air into the hollow ſtalk of the tree O, and from thence it paſſes, by the other branches, which are hollow likewiſe, to the fruit and flowers.

PLATE XXIV. p. 134.

Fig. 1. CADB a veſſel of water, in which one end of the ſyphon F is plunged, and being exhauſted of the air, the water runs out at the other end E.

Fig. 2. A ſucking pump. CD the piſton, EF two valves that open upward, MN the water in the well, H the pipe by which it runs out.

Fig. 3. The forcing pump. C a ſolid piſton, D a valve, H the pipe for conveying the water, in which is the valve E, through which the water is forced, by the piſton C, into the ciſtern F, from whence it runs out.

Fig. 4. The lifting pump. BD is an inverted piſton placed in the frame GEQHO; when this part is puſhed down the water aſcends through the piſton D, and when the the frame is drawn up, it is forced through the valve C, and out of the ciſtern at H.

PLATE XXV. p. 140.

Fig. 1. The ſimple hydrometer. B*b* a copper ball, in which is fixed the braſs wire AB; on this wire are ſeveral marks

marks which ſhow the different gravities of fluids, as in Fig. 2.

Fig. 3. The compound hydrometer. B is a hollow ball, to which is ſcrewed another ball *b*, filled with mercury. In the ball B is fixed a graduated wire AC. A is a ſmall weight that makes the wire deſcend the different depths, according to the gravity of the liquors.

Fig. 4. The hydroſtatic balance. From the point A is ſuſpended the bar BB, to which hangs the balance *b*, that is checked by the ſpring *zy*, ſupported by the piece M. From the bottom of each ſcale *c* and *d*, hangs a wire, that goes through the table; and to that from the ſcale *c*, is fixed another graduated wire *rs*, at the bottom of which is a weight L, and to that hangs a wire with a ſmall braſs ball *g*. T is an index, placed againſt the graduated wire *rs*. At the end of the wire that comes from the ſcale *d* hangs, by a horſe-hair, a glaſs tube R. The ſtring that goes over the point A paſſes down to the bottom of the ſtand, and is faſtened to the ſcrew P, by which the balance is raiſed or lowered.

PLATE XXVI. p. 142.

Fig. 1. The ſcrew of Archimedes. AB a cylinder, round which runs a pipe CD, whoſe lower end is immerſed in the water; D is the end of the pipe from whence the water iſſues; K the handle, ſupported by the piece IR.

Fig. 2. The hydraulic ſcoop. B the ſcoop; A the point from which the handle C is ſuſpended.

Fig. 3. The balance pumps. AB the balance; O, P, the pumps; M, N, the piſtons; HH the pipe through which the water is conveyed; F, G, are two ſprings to return the balance.

Fig. 4, ſhows the manner in which the balance moves on the points C.

Fig. 5. The hydroſtatic bellows. AB and EF two circular boards; AF and BE the ſides, which are of leather; DC a pipe ſcrewed into the board.

PLATE XXVII. p. 146.

Fig. 1. The water-cock. ABCD a glaſs veſſel, E a ſmall glaſs tube glued in the veſſel; GI another glaſs tube, to which hangs a weight L; F the cover of the veſſel.

Fig. 2. The hydraulic dancer. AB a figure made of cork; C a hollow cone placed under the figure.

Fig. 3. A hollow ball of copper placed on the top of a fountain.

Fig.

Fig. 4. The globular fountain. A is a hollow globe of copper, fixed on the pipe B, whofe orifice C is placed over a jet.

Fig. 5. The hemifpherical cafcade. In a hollow inverted cone A, is fixed a pipe B, and the water that falls from it runs over the fide of the cone C, in form of a hemifphere.

Fig. 6. The fame piece reverfed, when it forms a fountain in the figure of a vafe.

Fig. 7. The water fun. A is a hollow veffel in the middle of which are a number of holes, and the water that comes from the jet, on which it is placed, ruffhing through thofe holes, forms the refemblance of a fun, as in the adjoining figure.

Fig. 8. Several pieces, of the fame fort with the laft, placed over each other, in a horizontal direction, and all fupplied by the fame pipe.

PLATE XXVIII. p. 150.

Fig. 1. The revolving water-fun. A hollow circle, in which there are feveral holes, is fixed on the top of a jet, and as the circle turns round the water ruffhes out of the holes.

Fig. 2. The magic bottle. AB a bottle filled with wine; CD a veffel filled with water to the top of the bottle.

Fig. 3. The marvellous veffel; B the mouth of the veffel, which is filled with water and ftopped, and in the bottom A are feveral holes.

Fig. 4. The magical cafcade. AB a tin veffel that holds the water; DE a pipe fixed to the veffel; F, F, fmall tubes through which the water flows, GH the bafon to receive it.

Fig. 5. The circulating fountain. EC the box that contains the water; WA the bafon in which the fountain plays; WX the leg, by which the water runs into the box DX; YZ the leg through which the air is forced into the box EC.

Fig. 6. The compreffed jet d'eau. A is a copper veffel, in which there is a pipe BE, and in that another, G, that is fmaller; H is a cock to let out the air.

Fig. 7. The illuminated fountain. AB, and CD are two cylindrical veffels, that are connected by four tubes II, I, &c. and to each of thefe tubes candleflicks are fixed. At G is an aperture, by which water is poured into the veffel CD, and at K is the jet.

Fig. 8. The folar fountain. GNS is a thin hollow globe of copper. Through the leg C of the table AB paffes a pipe that goes to V. At K is a cock by which the fountain is ftopped.

PLATE

PLATE XXIX. p. 156.

Fig. 1. The cup of Tantalus. This cup is filled with water to S, and at A is placed an image that contains a syphon, which begins at one foot of the image, goes up to his breaſt, then down to the other foot, and out at the bottom of the veſſel.

Fig. 2. The ſea-gage. AB the gage bottle F*f* the tube, the lower end of which is immerſed in mercury; GH is a pipe of braſs that has ſeveral holes to admit the water into the bottle AB; K a weight that hangs by the ſhank L in the ſocket N; I is a large empty ball, fixed to the braſs tube H.

Fig. 3. An inſtrument to be added to the ſea-gage, to meaſure great depths. BCDF a hollow metal globe, to the top of which is fixed the long tube AB; at the part D of the globe is joined a ſhort tube DE, that is to ſtand in the mercury and treacle.

Fig. 4. The diving bell. AB the top of the bell: D a glaſs to admit the light; H a cock to let out the foul air; LM a circular ſeat for the divers to ſit on; C one of the barrels by which the divers are provided with freſh air; F a diver diſpatched at ſome diſtance from the bell.

Fig. 5. A diving bell for a ſingle perſon. AB the bell ſunk by weights at D; G, G, G, three glaſſes to admit the light, which are defended by the lids H, H, H; FFF chains that ſupport the ring E, on which the diver ſtands.

PLATE XXX. p. 168.

Fig. 1 and 2, are papers cut through with a piercer, and behind them a light is placed, by which they appear as illuminations.

Fig. 3, 4, 5, 6, and 8, are other papers of the ſame ſort as the laſt figures, but theſe are to revolve on a wire wheel, as Fig. 7.

Fig. 9, is an illumination where the fire appears to proceed in different directions.

Fig. 10. A double revolving wheel of fire, that at B proceeding in a different direction from that at A.

Fig. 11. The burning fountain. ABCD is a copper veſſel, in which is fixed the eolipile, that has a cock at G, and a ſmall pipe, F, with a very ſmall orifice.

PLATE

PLATE XXXI. p. 180.

Fig. 1. A wheel for repreſenting illuminations in various directions; A, A, &c. are pyramids that appear to turn on their centers.

Fig. 2 and 3. The apparatus for caſcades of fire. Fig. 2, the manner of piercing the paper. AB, Fig. 3, is a paper rolled on a cylinder, and as it is unrolled by the handle D the caſcade gradually appears.

Fig. 4. The manner of repreſenting a caſcade by a ſpiral.

PLATE XXXII. p. 191.

Fig. 1. The machine for the luminous oracle. ABCD a tin box. At M is a door in the back of the box, where the lights are placed in it; L, the opening in front, by which the objects are viewed.

Fig. 2. OP is double glaſs, between which a compoſition is put; on the back glaſs a picture is painted, and on the front glaſs a paper, divided into 45 parts.

Fig. 3. A pafteboard divided into 15 equal parts, ſimilar to thoſe in the laſt figure.

Fig. 4. ABCD a tin box. FGHI its pedeſtal, in which by the door at L, a chafing-diſh is placed. O a glaſs in the front of the box; R a flower placed in a tin tube.

Fig. 5. The box for the marvellous portrait. A the cover of the box, B its bottom, CD a falſe bottom, that draws out.

Fig. 6. The artificial hand. This hand is placed on a pedeſtal, covered with a thin ſtuff; at ST is an opening, and at I, a roller, by which the motion of the arm is facilitated. In the lower figure the elbow is joined to the piece F, that turns in two ſcrews C and D; the end F goes through a partition, and by that end an aſſiſtant moves the arm.

Fig. 7. The taliſman. ABC a triangular box; B a plate to be put at the bottom of the box; Q a copper triangle to be placed under the top of the box, and faſtened to the knob O.

PLATE XXXIII. p. 195.

Fig. 1. The box for the ſybils. AB a hollow pedeſtal; C a box that communicates with the pedeſtal. In the diviſions of the circle M are the names of the months, and the names of the days of the week. M is an index that turns freely on its center, and between ON is an opening into the

the pedeſtal, in which moves the bent index R. P is a pulley whoſe axis is directly under the center of the circle M. S and T two rollers, and at the end of T is a pulley V. X is a ſmall pully, round which goes a ſtring that communicates with P and T. D an opening in the front of the box, where the name of one of the ſybils appears

Fig. 2. The magic urn. AB a hole, in which the cylinder C, Fig. 3, is to be placed. D the top of the cylinder.

Fig. 4. The box for the incomprehenſible writing. DE, Fig. 5. ſhews the inſide of the top of the box; L, a plate of copper, to be placed in the part D of the top of the box.

Fig. 6, is a ſlip of paper GH, of the ſame ſize with the bottom of the foregoing box; at each end of this paper is wrote the name of a card.

Fig. 7. The oracular mirror. ABCD the mirror, which is moveable in the frame, and is ſeen under the glaſſes placed in the ſmall circles.

PLATE XXXIV. p. 208.

Fig. 1, and 2. The diſpoſition of the fingers in making the paſs.

Fig. 3, 4, and 5. The cards for the fifteen thouſand livres.

Fig. 6, 7, and 8. Cards for a recreation ſimilar to the laſt.

Fig. 9. The magic ring.

Fig. 10. The card in the mirror. B the part of the glaſs where the quickſilver is ſcraped off, and the card appears. CD and EF the grooves in which the mirror moves.

Fig. 11. The marvellous vaſe. AB the ſection of the vaſe; *cdefg* the diviſions in which the cards are placed; H the point to which a ſtring is fixed, that goes down the three ſmall diviſions, under the pulley I, through the bracket L, and comes out behind the partition M.

RATIONAL RECREATIONS.

ELECTRICITY.

DEFINITIONS.

1. ELECTRICITY is that property in bodies which enables them, when excited by friction or heat, to attract other light bodies, and produce an effluvium that is sometimes luminous, attended with a snapping noise, and a faint phosphoreal smell.

2. Electricity is called the second of the three species of attraction, gravity being the first, and magnetism the third.

3. Those bodies that produce electricity by friction or heat, are called electrics, and are said to be electric *per se*.

4. Those bodies that receive and communicate electricity are called conductors, and those that repel or will not suffer it to pass through them, are called non-conductors.

5. All bodies that are made to contain more than their natural quantity of electricity are said to be electrified positively, and those from whom part of their natural quantity is taken away, are said to be electrified negatively. These two electricities being first produced, one of them from glass, and the other from amber, wax or rosin, the former was called vitreous and the latter resinous electricity.

6. When a quantity of electricity is communicated to any body, it is said to be charged.

7. The effect of the explosion of a charged body,

that is the diſcharge of its electricity through any other body, is called the electric ſhock.

8. When any body is prevented from communicating with the earth, by the interpoſition of an electric body, it is ſaid to be inſulated.

9. The reſiduum of a charged body, as a jar or battery, is that part of the charge which remains in the body after the firſt diſcharge, and by which it will give a ſecond ſhock, though leſs than the firſt.

APHORISMS.

1. All ſubſtances are diſtinguiſhed into electrics *per ſe*, and non-electrics: the latter of which are conductors, and the former non-conductors.

2. All kinds of metals, ſemi-metals, water, charcoal, and other bodies of a ſimilar nature, are conductors; and all other bodies whether mineral, vegetable, or animal, are non-conductors: many of the latter, however, may be made to conduct electricity by being heated to a certain degree.

3. Poſitive electricity is produced by the friction of uninſulated glaſs tubes or globes; and negative electricity is produced either from the rubber of thoſe bodies, or from the friction of inſulated glaſs bodies; or laſtly, from the rubbing of globes or ſticks of wax, ſulphur, and other bodies of a ſimilar nature.

4. It follows from the laſt aphoriſm that the electricity of the excited body and the rubber, are always oppoſite, that is, if that of the excited body be poſitive, that of the rubber will be negative; and the contrary. Thoſe two bodies moreover will act on each other with greater force than any other body.

5. In charging any body, as a coated phial, if one ſide communicate with the excited body, and the other with the rubber, the electricity of the two ſides of the charged body will be oppoſite.

6. There is a ſtrong attraction between the two electricities on the oppoſite ſides of a glaſs, ſo that when they are made to communicate by means of a conductor

tor, they will be both diſcharged with a flaſh of light and a ſnapping noiſe.

7. The ſubſtance of glaſs is impervious to electricity; but if the glaſs be thin, and the electricity on the oppoſite ſides be very ſtrong, that is, if the glaſs be overcharged, the oppoſite electricities will force a paſſage through the glaſs.

8. If an excited electric be in contact with an inſulated conductor, the former will communicate its power to the latter, which will then attract light bodies, and give a ſpark, in the ſame manner as the excited electric.

9. The flaſh of light from a body to which electricity has been communicated, is more denſe, and the ſound louder, than from one that is excited; for the conductor parts with all its electricity at once, but the excited body with only ſo much as is at, or near, the part that is touched.

10. If inſulated bodies have been attracted by, and have touched an excited body, they will ſoon after be repelled by that body, and will repel each other; nor will they return to the excited electric till after they have touched ſome other body that communicates with the earth.

11. When an inſulated conductor is brought within the ſphere of action with an excited body, it acquires the electricity oppoſite to that of the body, and the nearer it is brought, the greater quantity it acquires; till the one receive a ſpark from the other, and then the electricity of both is diſcharged.

13. The electric exploſion always takes the ſhorteſt courſe through the beſt conductors.

13. If the exploſion between two bodies be interrupted by a non-conductor of a moderate denſity, the diſcharge will force a paſſage through it, in ſuch a manner as to leave the appearance of a ſudden expanſion of the air about the center of the exploſion.

14. If an inſulated conductor be pointed, or if an uninſulated conductor that is pointed, be brought very near the earth, there will be no other appearance of

electricity during the time of excitation than a light, and a current of air, that may be perceived to come from thoſe points.

15. The electric attraction acts in vacuo.

16. Electricity and lightning are in all reſpects of a ſimilar nature.

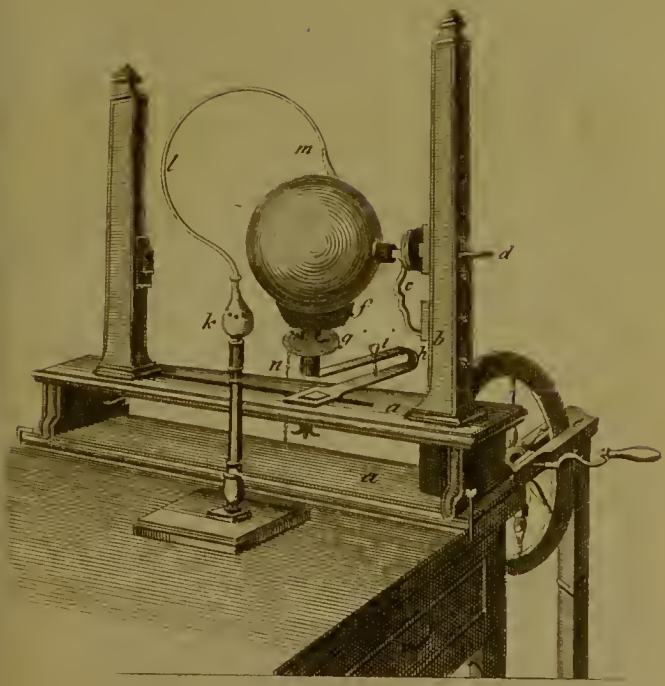
17. All the effects of lightning, may be imitated by electricity, and all the experiments in electricity may be performed by lightning, brought down from the clouds by means of an inſulated pointed rod of metal, as deſcribed in page 16, &c. of this volume; or by a kite, deſcribed in the ſeventeenth Recreation.

ELECTRICAL APPARATUS.

A deſcription of all the machinery that has been uſed in electrical experiments, would fill a volume. We ſhall here confine ourſelves to ſuch as are of general uſe, and neceſſary, in particular, to the following recreations: ſuch are the revolving globe and rubber, with its prime conductor, uſually called an electric machine; the electric battery; the fulmineous conductor; and the electrometer.

The conſtruction of the electric machine is as follows*. Let *aa*, Plate I. be two ſtrong boards of mahogany the lower about an inch on each ſide broader than the other: they are to be an equal length, parallel with each other, and about four inches aſunder. In the upper board is a groove that goes almoſt its whole length. The pillars are of baked wood: that marked *b* is immoveable, being fixed to the upper and lower boards; the other ſlides in the groove juſt mentioned that it may receive the globes or cylinders of different

* A great number of different electrical machines have been contrived. This appears to have been the invention of Dr Prieſtley, from whoſe Hiſtory of Electricity we have extracted the deſcription of the following apparatus, and the ſubſequent Recreations, ſome few articles excepted; for that valuable work contains every material diſcovery or improvement that has been hitherto made in this ſcience. A machine of a more ſimple conſtruction will be deſcribed farther on.


l
m
d
e
f
k
g
b
h
n
i
a

different dimenſions*, but is only neceſſary when they have axes. In each of the pillars there are holes at equal diſtances, by means of which the globes may be placed at a height adapted to their bulk. Theſe pillars are to be high enough to admit two or more globes at the ſame time. If two globes be fixed on one axis, four of a moderate ſize may be uſed, and the wheel may have ſeveral grooves for that purpoſe. When a globe with one neck is uſed, as in the plate, a braſs arm *c*, with an open ſocket, is neceſſary to ſupport the axis beyond the pulley: this part is alſo contrived to put higher or lower, together with the braſs ſocket in which the axis turns. The axis *d*, is made to come quite through the pillar, that it may be turned by a handle without the wheel, at the option of the operator. As the frame ſcrews to the table, it may be placed at different diſtances from the wheel, in proportion to the length of the ſtring, in different ſtates of the air. The wheel is fixed in a ſeparate frame *e*, by which means it may be placed in any ſituation, with reſpect to the pulley, and be turned to one ſide, ſo as to prevent the parts of the ſtring from cutting each other. The back part of this frame is ſupported by a ſeparate foot†.

The rubber *f*, conſiſts of a hollow piece of copper, ſtuffed with horſe hair, and covered with a baſil ſkin. It is ſupported by a ſocket, that receives the cylindrical axis of a round flat piece of baked wood *g*, the oppoſite part of which is inſerted into the ſocket of a bent

* It is not yet determined what ſort of glaſs is moſt proper for theſe globes and cylinders. The beſt flint is uſed, but Dr Prieſtley ſeems to think, that common bottle-metal is the moſt eligible. Some operators line their globes or cylinders with wax, or ſome other electric ſubſtance; which in large globes may be of good uſe; but when they are ſmall, no material advantage can be expected from any lining.

† Some electric machines are turned by a braſs toothed wheel and pinion, incloſed in a box, which has a more elegant appearance; but theſe wheels are ſubject to accidents, which are not ſo eaſily repaired as thoſe that happen to a ſtring.

ſteel ſpring *b**. Theſe parts are eaſily ſeparated; ſo that the rubber, on the piece of wood by which it is inſulated, may be changed at pleaſure. The poſition of the ſpring may be altered two ways: it may either be ſlipped along the groove, or moved in the contrary direction, ſo as to give it every deſireable poſition with regard to the globe or cylinder: and it is, beſides, furniſhed with a ſcrew *i*, which makes it preſs harder or lighter, as the experiment may require.

The prime conductor *k*†, is a hollow veſſel of poliſhed copper, in the form of a pear, ſupported by a pillar on a firm baſis of baked wood‡; and it receives its

* If the rubber be very narrow, ſome parts of the globe will paſs without a ſufficient friction: to remedy this inconvenience, an apron of oiled ſilk, ſuch as is uſed for umbrellas, may be faſtened to the rubber, to ſupply the deficiency. There ſhould be no ſharp edges or angles about the rubber, for they would make its inſulation, which is a matter of great conſequence, ineffectual.

† For common purpoſes a ſmall conductor is moſt convenient; but when a ſtrong ſpark is wanted, it is proper to have a large conductor ready, which may be placed in contact with the ſmaller. But whatever be the ſize of the conductor, that part which is moſt remote from the globe ſhould be round, and much larger than the reſt: for the effort of the electric matter to fly off, is always the greateſt at the greateſt diſtance from the globe; and from that part the longeſt and ſtrongeſt ſparks may be drawn.

The largeſt and moſt pungent ſparks are drawn from any conductor along an electric ſubſtance. Thus if the conductor be ſupported by pillars of glaſs or baked wood, the longeſt ſparks will be taken cloſe to the pillar.

If part of the conductor be concave, a remarkable large, ſtrong, and undivided ſpark may be drawn from the concavity. Where the ſurface is convex, the ſpark is more apt to be weak and divided.

‡ Baked wood is found by experience to form a perfect inſulation, but it requires to be baked again at different times, eſpecially if it be kept in a damp ſituation. A pillar of glaſs varniſhed with ſealing wax will anſwer exceeding well, and does not require ſo much attention. The beſt method of varniſhing a glaſs is to diſſolve ſo much ſealing-wax, in ſpirit of wine, as will make it of a due conſiſtence. It may then be laid on the glaſs, by a bruſh, with very little trouble.

Dr Prieſtley adviſes electricians to make all their ſtands and tools for inſulation, of baked wood; as it may be eaſily turned into

its electricity by means of a long arched wire, or a rod of very ſoft braſs *l*, eaſily bent into any ſhape, and raiſed higher or lower as the globe may require: it is terminated by an open ring, in which are hung ſome ſharp-pointed wires or needles *m*, that play lightly on the globe when it is in motion.

The body of the conductor is furniſhed with holes and ſockets, for the inſertion of metallic rods, to convey the fire wherever it is wanted; and for many other purpoſes, incident to a courſe of electrical experiments. The conductor is by this means ſteady, and yet may be eaſily put into any ſituation. It collects the fire perfectly well, and (what is of the greateſt conſequence, though but little regarded) retains it equally every where.

When poſitive electricity is wanted, a wire or chain, as is repreſented in the plate at *n*, connects the rubber with the table or floor. When negative electricity is wanted, that wire is connected with another conductor, ſuch as that repreſented at *t*, Pl. II. while the other conductor in Pl. I. is connected, by another wire or chain, with the table. If the rubber be made tolerably free from points, the negative power will be as ſtrong as the poſitive.

The principal advantages of this machine are, that glaſs veſſels, or any other electric body, of any ſize or form, may be uſed, either with one or two necks. All the eſſential parts of the machine, as the globe, the frame, the wheel, the rubber, and the conductor, are quite ſeparate, and the poſition of them to each other may be varied in every manner poſſible. The rubber has a complete inſulation, by which means the operator

into any form; as it inſulates better than glaſs, and is not ſo brittle. But care muſt be taken that the wood be thoroughly baked, even till it be quite brown: it will not then be very apt to collect moiſture from the air: if it ſhould, a little warming and rubbing will be ſufficient to expel that moiſture. At moſt, it can only be neceſſary to boil it in linſeed oil, or give it a ſlight coating of varniſh after it comes out of the oven. When this preparation is uſed, it muſt be well heated once more, immediately after the boiling.

operator may command either the negative or positive power, and may change them in an inſtant. This conductor is ſteady, and eaſily enlarged, by placing rods in the holes with which it is furniſhed, or by the conjunction of other conductors in order to give larger ſparks, &c. It may be turned either with or without the wheel, ſo that the operator may ſit or ſtand to his work, at his option; and he may, with the utmoſt eaſe, manage the machine and the other parts of the apparatus*.

When the air is dry, particularly when there is a froſt, and the wind is north or eaſt, there is ſcarce any electric machine but will work very well. If the air be damp, make a large fire in the room where the machine ſtands, and let the globe, and every thing about it be made very dry: it will then work almoſt as well as in the beſt ſtate of the air.

To increaſe the quantity of electric fire from a globe, let the rubber be a little moiſtened, from time to time; or rather, moiſten the under ſide of a looſe piece of leather, that may occaſionally be put upon the rubber. But the moſt powerful exciter is a little amalgam, made by rubbing mercury and thin pieces of lead or tinfoil together, in the palm of the hand. If a rubber be at any time placed perpendicular to the horizon, it will be neceſſary to uſe a little tallow or pomatum to make it ſtick. With this excellent reſource, almoſt all ſorts of weather become equally fit for electrical experiments.

A little time after freſh amalgam has been put upon the rubber, and often at other times, if there be any foulneſs upon the cuſhion, and ſometimes when there is

* We are informed that Dr Prieſtley, ſince the publication of his Hiſtory, has contrived a windmill, to be placed on the top of his houſe, by which his electrical machine is occaſionally turned. One or more globes, excited by the force of a ſtrong wind, muſt doubtleſs produce a very great quantity of electricity; and from that gentleman's extenſive knowledge of this ſcience, and his unwearied application to the improvement of experimental philoſophy, the learned world has reaſon to hope for ſome farther important diſcoveries in electricity.

is none, there will be found upon the globe ſmall black ſpots, of a hard rough ſubſtance, which grow continually larger, till a conſiderable quantity of that matter be accumulated upon the ſurface. This muſt be carefully picked off, or it will obſtruct the excitation, and in a great meaſure defeat the intended operation.

When the amalgam has been uſed for ſome time, there will be formed upon the rubber, a thick incruſtation of the ſame kind of black ſubſtance that is apt to adhere to the globe. This incruſtation is a very great improvement of the rubber; for when once a conſiderable body of it is formed, and it is a little moiſtened or ſcraped, as much fire will be produced as if freſh amalgam were uſed; ſo that it ſeems to ſuperſede the farther uſe of the amalgam.

As the electric matter is collected only at the rubber, it is neceſſary that it have a communication with the common maſs of the earth, by means of good conductors. If, therefore the table on which the machine ſtands, or the floor of the room in which it is uſed, be very dry, little or no fire will be got, be the machine ever ſo good. In this caſe it will be neceſſary to connect the rubber, by means of chains or wires, with the floor, the ground, or even the next water, if the neighbouring ground be dry.

If the conductor be made perfectly well and the air be dry, there will never be any loſs of fire from any part of it; for when the whole ſurface has received as high a charge as the machine can give, it will, in all places alike, perfectly reſiſt all efforts to throw any more upon it, and the circulation of the fluid by the rubber will be ſtopped, being balanced, as it were, by equal forces. Or if it loſe, in all places alike, the diſſipation muſt be inviſible. This maxim almoſt admits of ocular demonſtration; for when the rubber is perfectly inſulated, and the conductor has an opportunity of diſcharging itſelf, the rubber will take ſparks from a wire placed near it very faſt; but when the conductor has but little opportunity of diſcharging itſelf, it will take fewer of thoſe ſparks.

The

The larger the conductor is, the ſtronger ſparks it will give: for the greater the electric ſurface, the greater quantity of the electric atmoſphere it contains, and the more ſenſible its effects will be, when it is all diſcharged at once. The conductor, however, may be made ſo large, that the neceſſary diſſipation of the electric matter from its ſurface into the air, will be equal to the ſupply from the machine, which will conſtitute the maximum of the power of that machine, and which will be different in different ſtates of the air.

To form a juſt eſtimate of the electric power of different machines, take two wires, with knobs of any ſize, and fix one of them at the conductor of one of the machines, and the other wire about an inch or an inch and a half from it: and as the wheel turns, count the number of ſparks that paſs between them in any given time. Fix the ſame wires to the conductor of another machine (but if the ſame conductor were uſed the trial would be more exact) and the difference between the number of ſparks in the given time will determine the difference of ſtrength in the two machines*.

The

* For common purpoſes there are electric machines conſtructed without either globe, cylinder, or wheel, as thus: let two upright pieces of wood, of about two feet long, be joined at bottom by a croſs piece, and let there be a gripe to faſten them to a table, or any horizontal board. Againſt the inſide of each of the perpendicular pieces fix a leather cuſhion, and let there be a hole made through each piece and cuſhion, oppoſite to each other. Then take a plate of glaſs about a foot ſquare, through the middle of which let a workman make a hole, of the ſame ſize with thoſe in the poſts and cuſhions: if theſe holes be about nine inches from the top, you may work the machine either ſitting or ſtanding. Through all the holes let an axis be paſſed, that has a handle at one end. The cuſhions are to preſs hard againſt the glaſs.

Next, provide a conductor, which may conſiſt of a ſmall iron rod, faſtened by ſealing-wax to an upright piece of wood, ſupported by a glaſs veſſel of any ſort; from the rod muſt go a wire, at the end of which are to be two large needles, that communicate with the two ſides of the glaſs; and from each of the rubbers there muſt go a chain to the floor or table. When poſitive electricity is wanted, the needles are to communicate with the glaſs; and when

The electric machine being thus completely adjuſted, the operator will next want metal rods to conduct, and coated glaſs jars or phials to retain and communicate the electric fire. Metallic rods, ſuch as *s*, Plate II. uſed in taking ſparks from the conductor for various purpoſes, ſhould have knobs, of different dimenſions, in proportion to the curvature of the conductor. If the knob be too ſmall, it will not diſcharge the conductor at once, but by degrees, and with leſs ſenſible effect; whereas the ſpark between broad ſurfaces is thick and ſtrong.

The moſt formidable part of the electric apparatus is the coated glaſs, uſed in the Leyden experiment* and the battery. The form of the glaſs is immaterial with reſpect to the ſhock; but for different experiments both plates and jars, of various ſhapes and ſizes, muſt be uſed. The moſt commodious form, for common uſe, is that of a jar, as wide as a perſon can conveniently graſp, and as tall as will ſtand without danger of falling: perhaps about three inches and a half diameter, and about eight inches high. The mouth ſhould be pretty open, that it may be the more conveniently coated on the inſide, as well as on the outſide, with tin-foil: but it will be generally moſt convenient to have the mouth narrower than the belly, for then it may more eaſily be kept clean and dry, and the cork, when one is wanted, will be eaſier to manage. A jar thus prepared, of a moderate ſize, is called the Leyden phial. But no electrician could be without jars of various forms and ſizes. The figures of ſeveral of them are expreſſed in Plate II. at *c*, *d*, *e*, *f*, *g*, *h*, *i*, *j*, and *k*. The form of a plated coat of glaſs is repreſented at *b*.

The practice of coating jars is far preferable to that of putting water, or braſs ſhavings, into them, which not

when negative electricity, with the cuſhions. With this machine and a little care and practice you will be enabled to perform all the common operations in electricity.

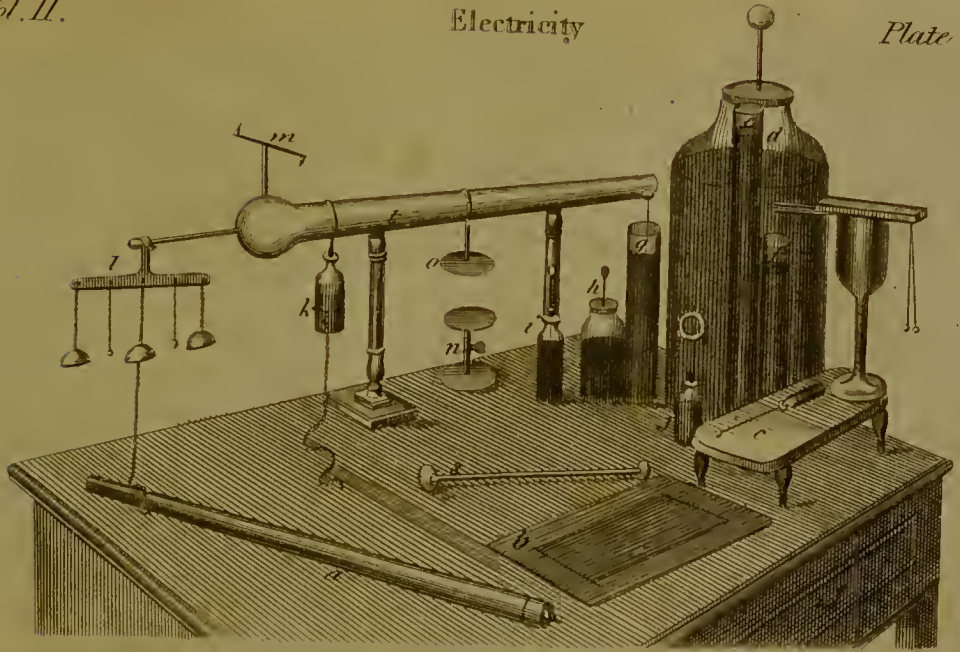
* By the Leyden experiment is here meant the ſhock that is given by two wires, communicating with the two ſides of a charged coated glaſs or phial.

not only makes them heavy, but incapable of being inverted, which is requiſite in many experiments. Braſs duſt, or leaden ſhot, are, however, very convenient for ſmall phials, and ſerve very well where it is neceſſary to remove the coating as ſoon as the jar is charged, but in this caſe quickſilver will generally anſwer beſt. The tin-foil may be put on either with paſte, gum-water, or bees wax. To coat the inſide of veſſels that have narrow mouths, moiſten the inſide with gum-water, and then pour ſome braſs duſt upon it; enough will ſtick on to make an exceeding good coating, and will not eaſily come off, unleſs ſomething very hard rub againſt it.

Being thus provided with a machine to produce, and jars to receive, the electric matter, it will be proper, in the next place to conſtruct an electrometer, that you may know when your jars are ſufficiently charged*. There have been many different inventions for that purpoſe. That of Mr Canton is one of the moſt ſimple, and is uſeful on many occaſions. It conſiſts of two pieces of cork, or pith of elder, nicely turned in a lathe, to about the ſize of a ſmall pea, and ſuſpended on fine linen threads, repreſented at *c*, Plate II. on a glaſs, ſtanding on a ſtool. It is convenient to place them in a ſmall box for the pocket; the box ſhould be the full length of the ſtrings, that they may lie in without being bent†. Theſe balls not only ſhow when a jar

* The moſt effectual method of charging a jar, is to connect the outſide, by means of wire, with the rubber, while the wire, proceeding from the inſide is in contact with the conductor. In this manner the inſide of the jar will be ſupplied with the very ſame fire that left the outſide. In this caſe alſo the jar will receive as high a charge as it is capable of receiving, though the rubber be inſulated, and have no communication but with the outſide coating; ſo that in the caſe of charging, there can be no occaſion for the directions given above, when the table, the floor, or the ground are very dry. When a thin jar is diſcharged, it is adviſeable not to do it by placing the diſcharging rod oppoſite the thinneſt part, as it will endanger the burſting of the jar in that part.

† If a ſmooth cork ball be hung on a long ſtring of ſilk, and electrified poſitively, it will always be repelled by poſitive, and attracted by negative electricity.


m
l
k
e
o
n
d
h
i
f
g
a
b
c

jar has a ſufficient charge, but alſo diſcover a very ſmall degree of electricity, and mark its changes from poſitive to negative, and the contrary*.

But the moſt ſenſible of all electrometers conſiſts of two or three threads of ſilk, as they come from the worm, to which is faſtened a piece of down, that is juſt ſufficient to keep them perpendicular to the horizon. If inſulation be neceſſary, faſten them to a piece of baked wood. When the ends of theſe threads have received a ſmall degree of electricity, they will retain it a conſiderable time, and the ſlighteſt electric force will put them in motion†. But before any experiment be made, it will be proper to obſerve carefully, how long they will retain the degree of electricity that is intended to be given them, in any ſituation, and a proportionable allowance is to be made in the courſe of the experiments.

The only inſtrument, however, that can with propriety be called an electrometer, that is ſuch as meaſures

* If two pith balls, hung by linen threads, and diverging with poſitive electricity, be inſulated; though in connection with conductors of conſiderable length, the approach of a body electrified poſitively, will firſt make them ſeparate, and then (if the electricity of the balls be ſmall, and that of the approaching body great) it will at a certain diſtance make them approach, and at length come into contact with it. Sometimes the divergence, previous to the convergence is very ſmall, and without great attention, is apt to be overlooked.

If the balls have a free communication with the earth, for inſtance, if they be held in the hand of a perſon ſtanding on the ground, and (as in the former caſe) they may be made to diverge with poſitive electricity, in conſequence of being held within the influence of a body electrified negatively, the approach of poſitive electricity will make them converge; and negative electricity diverge: the electric matter of the approaching body, in the former caſe, repelling that of the balls, and thereby as it were, inelectrifying them; whereas, in the latter caſe the negative electricity of an approaching body draws it more powerfully into the threads and makes them diverge more. This method of judging is, therefore, excellently adapted to aſcertain the kind of electricity in the atmoſphere, or of a charged jar or battery; the balls being held in the hand of a perſon ſtanding on the earth or floor.

† Theſe threads will diſcover a ſmaller degree of electricity than can be eaſily perceived by the balls.

ſures the preciſe degree to which any body is electrified, was invented by Mr Henly, and is deſcribed in the Philoſophical Tranſactions, in a letter from Dr Prieſtley to Dr Franklin, and is as follows: A (Plate III. Fig. 1.) is a very light rod, that turns on the center of a ſemicircle B, ſo as always to keep pretty near its graduated limb: at the extremity of the rod is a cork ball C. D is the pillar that ſupports the rod, and may be either fixed on the prime conductor, or let into the braſs knob of a jar or battery, or be ſet on a ſtand to ſupport itſelf. The whole inſtrument may be made of wood or ivory, but is found moſt perfect when the pillar and rod, or index, are of box, made very ſmooth with emery paper: the ball of cork, and the ſemicircle ivory, as the diviſions on that are more legible than on wood.

The moment this inſtrument begins to be electrified, the cork ball is repelled by the pillar, and conſequently begins to move the rod over the edge of the ſemicircle, and ſhows, to the greateſt preciſion, the degree to which the prime conductor is electrified; or how high any jar or battery is charged. As the materials of which this inſtrument are made, are very imperfect conductors, it will very rarely diſſipate any of the electricity of the prime conductor, &c. with which it is connected; but if it be found, by a trial in the dark, that any part of it collects the electric matter, it muſt be placed before the fire to dry off the damp, particularly from the index; it ſhould not, however, be much heated, for then it will not receive the electricity ready enough and the motion of the index will not anſwer with ſufficient accuracy, to the degree of electricity in the body with which it is in contact; but this inconvenience may be eaſily remedied by moiſtening the pillar and the index; for the ſemicircle can never be dry.

It is evident, from the conſtruction of this inſtrument, that the force of different exploſions may be aſcertained by it, before the diſcharge, with the greateſt accuracy. If a jar be charged with poſitive electricity

tricity, and you want to know the precise time, while you are attempting to charge it negatively, that it becomes discharged, watch the moment the index comes to the perpendicular station, which may be observed without the least danger of a mistake, and you will then find there is not the least spark left in the jar. If you continue the operation, the index will begin to advance again; and thereby show the exact quantity of the opposite electricity the jar has acquired.

The electrical battery is composed of a number of coated jars, enclosed in a case, as in Fig 2. Plate IV. Very large jars are not the most eligible; those that are smaller contain a greater coated surface in proportion to their bulk; and it is by that the force of a battery is produced. The largest jars that can be conveniently made are about 17 inches high, and they should not be more than 3 inches in diameter, and every where of an equal width.

The battery used and recommended by Dr Priestley, consists of 64 glass jars*, each 10 inches high, and two inches and a half diameter, and coated to within one inch and a half of the top. The coated part of each is, therefore, half a square foot; so that the whole battery contains 32 square feet. The wire of each jar has a piece of very small wire twisted about the lower end of it, to touch the inside coating in several places, and it is put through a pretty large piece of cork, within the jar, to prevent any part of it touching the side, which would tend to promote a spontaneous discharge†. Each wire is turned round so as to make a hole at the upper end, and through these holes is put a pretty thick brass rod with knobs; one rod serving for one row of the jars.

* A less number, however, will be quite sufficient for common purposes: on the contrary, where a very great force is wanted, two or more batteries may be connected, and separate jars added to them.

† Instead of this wire with a cork, the jars of some batteries have wires bent double, whose lower parts are springs, so that they touch the sides of the jar next the bottom, without coming near the top.

The communication between these rods is made by laying over all of them a chain, which is not drawn in the plate, lest the figure should appear confused. When you would use only a part of the battery, you lay the chain over as many rods as you want rows of jars. The bottom of the box, on which these jars stand, is covered with tin foil and brass dust; and a bent wire, touching the tin-foil, is put through the box, and appears on the outside as in the figure. To this wire is fastened whatever is intended to communicate with the outside of the battery, as the piece of small wire in the figure; and the discharge is made by bringing the brass knob to any of the knobs of the battery. The glass of which this battery is made, is what the workmen call flint green, which Dr Priestley thinks much better for this purpose than the best flint, as jars made of it are not so apt to discharge themselves; and it is moreover much cheaper.

In order to judge of the strength of a charge (which in large batteries is a matter of considerable consequence) apply the electrometer to the wires, from time to time. A comparison of the degree of the divergence of the balls, compared with the actual explosion, will soon enable the operator to tell how high his battery is charged, and consequently what will be the force of the explosion.

You are not to conclude, because you can touch the wires of a large battery without any effect, that therefore, while your hand is upon them, you can safely touch the outside coating with the other hand; for sometimes when the wires have shown no signs of a charge, and even two days after the battery has been discharged, very violent shocks have been received. Therefore, soon after the first explosion, it is proper to discharge the residuum for fear of a disagreeable accident. When the box is very dry, there will sometimes remain even the residuum of a residuum, for several days.

The best construction of a fulmineous conductor, that is, a machine to draw down electricity or lightning

ning from the clouds is as follows. On the top of any building which will be more convenient if it ſtand on an eminence, erect a pole *a* (Pl. III. Fig. 2.) as tall as a man can well manage, having on its top a ſolid piece of glaſs, or baked wood, a foot long; over which fix a tin or copper veſſel *b*, in form of a funnel, to preſerve it conſtantly from the rain; above this let there riſe a long ſlender rod *c*, terminating in a pointed wire, and having a ſmall wire twiſted round its whole length, to conduct the electricity the better to the funnel. From the funnel let a wire *d*, deſcend along the building, at about a foot diſtance from it, and be conducted through an open ſaſh, into the room that is moſt convenient for performing the experiments. In this room let a proper conductor be inſulated, and connected with the wire that comes in at the window. This wire and conductor being completely inſulated, will be electrified whenever there is a conſiderable quantity of electricity in the air: and notice will be given when it is properly charged either by the pith balls hung to it, or by ſuch a ſet of bells as will be hereafter deſcribed.

To make experiments with this apparatus in perfect ſafety, the electrified wire ſhould be brought within a few inches of a conducting rod, which ſerves to guard the houſe, that the redundant electricity may paſs off that way without ſtriking any perſon who may chance to ſtand near it. The conductor to guard the houſe ſhould conſiſt of one rod, between one-fourth and one-half of an inch thick, if it be of iron, but ſmaller, if it be of braſs or copper, and terminating upward in a ſharp point, about four or five feet above the higheſt part of the building; and below, it ſhould, if poſſible, be continued to ſome well or running water; if not, it ſhould be ſunk ſeveral feet into the ground, at the diſtance of ſome yards from the building. It is of no conſequence whether this conducting rod be faſtened to the inſide or outſide of the houſe, or how many bendings there are in it.

Beſide theſe principal parts of an electrical apparatus, the operator will frequently find it very convenient, when only ſmall quantities of electricity are required, to be provided with tubes and cylinders of glaſs, and ſticks of wax or ſulphur.

Glaſs tubes ſhould be made as long as a perſon can well draw through his hand at one ſtroke, that is about three feet, or ſomething more, and as wide as can be conveniently graſped. It is not neceſſary that the glaſs be thick; perhaps the thinner the better, if it will bear ſufficient friction, which, however, need be but very gentle, when the tube is in good order. It is moſt convenient to have the tube cloſed at one end; for the electric matter is not only thereby beſt retained on its ſurface, but the air may be more eaſily drawn out, or condenſed in it, by means of a braſs cap fitted to the open end. A tube thus furniſhed is repreſented at *a*, Plate II. and is requiſite for various experiments.

The beſt rubber for a ſmooth glaſs tube is the rough ſide of a black oiled ſilk, eſpecially when a little amalgam of mercury and any metal, is put upon it. A little bees wax drawn over the ſurface of a tube will alſo greatly encreaſe its power. In rubbing a tube, the hand ſhould be kept two or three inches below the upper part of the rubber, otherwiſe the electricity will diſcharge itſelf upon the hand, and nothing will remain upon the tube for the experiment. When the tube is in very good order, and ſtrongly excited, it will throw off many pencils of rays at every ſtroke, without the approach of any conductor, except what moiſture may float in the common atmoſphere.

An electrician ſhould alſo be furniſhed with rough glaſs tubes, that is, ſuch as have their poliſh taken off; though a cylinder of baked wood will do nearly as well. The beſt rubber for a rough glaſs tube, or cylinder of baked wood, as well as for a ſtick of wax or ſulphur, is ſoft new flannel; or rather ſkins, ſuch as hare or cat-ſkin, tanned with the hair on, being ſmoother, and having a more exquiſite poliſh.

Such

Such is the common conſtruction of an electrical apparatus; but to make this part of our work correſpond with the reſt, by adding ſurprize to learning and ingenuity, it will be neceſſary to conceal the apparatus by placing it in an adjoining room. For which purpoſe, let the table *a*, *b*, *c*, *d*, (Plate III. Fig. 3.) be placed againſt the partition X, that ſeparates the two rooms. Let the branch ABC be joined at A to the prime conductor in the other room: round the part A muſt be a piece of wood, baked and prepared as is deſcribed in the account of the apparatus; this piece muſt be made to take out, that it may be heated by the fire, in damp weather, before the exhibition begins, and muſt be nicely fitted to the wainſcot, that it may not occaſion ſuſpicion of any communication. The knob at C muſt be larger than uſual, that it may give the larger ſnap. The branch being thus joined to the prime conductor, will anſwer all the purpoſes of the conductor itſelf, and larger ſnaps will be taken from C than from any part near the globe.

In each ſide of the top of the table between *a e* and *b f*, muſt be concealed a glaſs tube that communicates with the other room, and in theſe tubes muſt be placed the two chains that come from the two ſides of a jar or battery, only one link of which, however, is to be ſeen at *e* and *f*, which may appear as hooks faſtened to the table: to theſe hooks two other chains or wires are to be faſtened, when an exploſion is wanted.

Certain words or phraſes muſt be agreed on between the operator and his aſſiſtant, by which the latter may know when he is to charge the conductor, or connect the chains with the jar or battery. There ſhould likewiſe be a ſmall hole in the partition, by which he may guide himſelf with more certainty. Under the table may be a drawer, that may be pulled out occaſionally, to ſhow that there is nothing concealed.

To the foregoing apparatus it may be proper to add ſome account of the tourmalin, a ſubſtance that has been uſed in electric experiments but few years paſt, but is ſuppoſed to be the lyncurium of the ancients, to which

which they attributed ſome electric properties. This ſtone is common in ſeveral parts of the Eaſt, and particularly in the iſland of Ceylon, from whoſe inhabitants it received its preſent name*.

The tourmalin is a foſſil of a hard and very compact ſubſtance of a deep red colour and pellucid. Its principal properties are thus deſcribed by Mr Canton, in the Gentleman's Magazine for September 1757.

1. When the tourmalin is not electrical or attractive, heating it, without friction, will make it ſo; and the electricity of one ſide of it (diſtinguiſhed by A) will be poſitive, and that of the other ſide (B) will be negative.

2. The tourmalin not being electrical, will become ſo by cooling; but with this difference, that the ſide A will be negative, and the ſide B poſitive.

3. If the tourmalin, in a non-electric ſtate, be heated, and ſuffered to cool again without either of its ſides being touched, A will be poſitive, and B negative, the whole time of the increaſe and decreaſe of its heat.

4. Either ſide of the tourmalin will be poſitive by friction, and both may be made ſo at the ſame time.

Mr Canton obſerved farther, that it is not heat, but the circumſtances of changing its degree of heat, that gives electricity to this ſtone.

Dr Prieſtly has ingeniouſly remarked, that a pleaſing deception might be made by encloſing a tourmalin, in a thin coat of ſealing-wax; for the coat will then ſeem to have acquired the properties of the tourmalin.

We have been more minute in the deſcription of this apparatus than may ſeem neceſſary to the performing the following recreations: but it is from the definitions and aphoriſms, together with a deſcription of the apparatus, that a knowledge of the ſeveral branches of ſcience contained in this work, is to be acquired;

* Since the uſe of the tourmalin in electricity, it has been diſcovered that ſome ſtones or gems, particularly the Brazil topaz, have ſimilar properties.

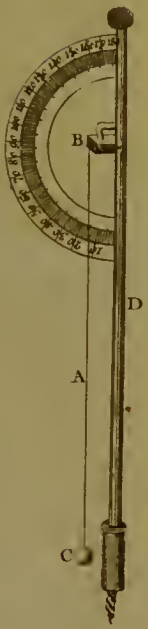
Fig. 2.



Fig. 4.



Fig. 1.



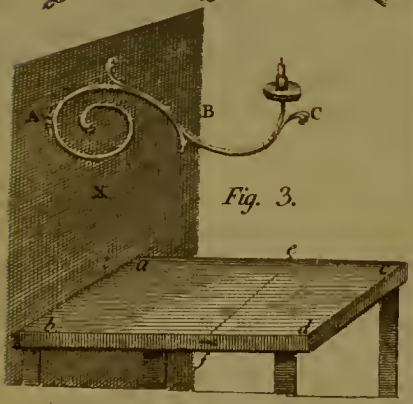


Fig. 3.

quired; the recreations being principally intended to exemplify what is there laid down. Beſide, a perſon of ingenuity, in poſſeſſion of this electric apparatus, may invent a great number of ſimilar recreations; which being the produce of his own mind, will, perhaps, be found more entertaining than any here deſcribed; and at the ſame time may, ſome of them, tend to the further ecclairciſſement of this very pleaſing branch of experimental philoſophy.

ELECTRICAL RECREATIONS.

We ſhall divide theſe Recreations into ſuch as are performed in the light, and ſuch as require a dark chamber; beginning with the former.

RECREATION I.

The animated feather.

ELECTRIFY a ſmooth glaſs tube with a rubber, and hold a ſmall feather (or piece of leaf gold) at a ſhort diſtance from it. The feather will immediately fly to the tube, and adhere to it for a ſhort time, and then fly off, and the tube can never be brought cloſe to the feather till it has touched the ſide of the room, or ſome other body that communicates with the ground. If therefore the operator take care to keep the tube conſtantly between the feather and the ſide of the room, he may drive it round to all parts without touching it; and what is very remarkable, the ſame ſide of the feather will be conſtantly oppoſite the tube.

While the feather is flying before the ſmooth tube, it will be immediately attracted by an excited rough tube, or a ſtick of wax, and fly continually from one tube to the other, till the electricity of both is diſcharged*.

This

* This feather not badly repreſents one of that deſpicable ſort of women they call coquettes; who when an excited ſuitor appears, readily flies to him, but preſently quits him. If another ſuitor appear, ſhe in like manner flies to him, and in like manner leaves

This was one of the firſt, and is one of the moſt common experiments in electricity; it is however very entertaining, and ſhows the nature of electric attraction and repulſion altogether as well as a more elaborate performance.

RECREATION II.

The ſelf-raiſing pyramid.

PROVIDE a large circular bundle of threads, of different colours, and let the threads be alſo of different lengths, increaſing from the circumference to the center, where they are to be longeſt. Suſpend this bundle from the middle of the braſs arch between the pillars (Plate III. Fig. 3.) Then inform the company that the threads will riſe up, at their command, in form of a pyramid, and continue in that form as long as they direct, and then return to their firſt poſition.

Therefore, when they command the threads to riſe, you give the ſignal to the operator behind the partition, who, by turning the wheel, electrifies the arch, when the threads will immediately riſe up, in form of a pyramid, and continue ſo, as long as the operator continues turning the wheel; but when that ſtops they will immediately return to their former poſition.

RECREATION III.

The magical dance.

FROM the middle of the braſs arch ſuſpend three ſmall bells, in the ſame manner they are ſuſpended from the end of the conductor in Plate II. at *l*. The two outer bells hang by chains, and that in the middle by a ſilk ſtring, while a chain connects it with the floor. Two ſmall knobs of braſs, which ſerve as clappers, hang, by ſilk ſtrings, one between each two bells. Therefore when

leaves him: and then, unleſs a third party appear, is continually changing from one to the other; till at laſt they both grow tired of her, and ſhe then remains as inſignificant and contempt ble as a mere feather.

when the two outer bells, communicating with the conductor, are electrified, they will attract the clappers, and be ſtruck by them. The clappers being thus loaded with electricity, will be repelled, and fly to diſcharge themſelves upon the middle bell; after which they will be again attracted by the outer bells: and thus, by ſtriking the bells alternately, the ringing may be continued as long as the operator thinks proper*.

The muſic for your dance being thus provided, you are next to ſuſpend a plate of metal from the ſame part of the arch to which the bells are connected: at the diſtance of a few inches from the arch, and exactly under it, place a metal ſtand of the ſame ſize, in the ſame manner as at *o* and *n* in Plate II. On the ſtand place ſeveral figures of men, other animals, or what you pleaſe, cut in paper or leaf gold, and pretty ſharply pointed at both extremities†.

When the plate that hangs from the arch is electrified, the figures will dance with amazing rapidity, and the bells at the ſame time ringing inceſſantly, will afford no ſmall entertainment to the ſpectators. This Recreation may be ſtopped and renewed at pleaſure, in the ſame manner as the laſt.

RECREATION IV.

The artificial ſpider.

CUT a piece of burnt cork, about the ſize of a pea, into the form of the body of a ſpider; make its legs of

* In the dark a continual flaſhing of light will be ſeen between the clappers and the bells, and when the electrification is very ſtrong, theſe flaſhes of light will be ſo large, that they will be tranſmitted by the clapper from one bell to the other, without its ever coming into actual contact with either of them; and conſequently the ringing will ceaſe.

† If a piece of leaf gold be cut with a pretty large angle at one extremity, and a very acute angle at the other, it will want no ſtand, but will hang, by its large angle at a ſmall diſtance from the conductor, and by the continual waving motion of its lower extremities, will have the appearance of ſomething animated, biting or nibbling at the conductor. It is therefore called by Dr Franklin the Golden Fiſh.

of linen thread, and put a grain or two of lead into it to give it more weight. Suſpend it by a fine line of ſilk between the electrified arch and an excited ſtick of wax, and it will, like a clapper between two bells, jump continually from one body to the other, moving its legs at the ſame time, as if animated; to the no ſmall ſurprize of thoſe who are unacquainted with the electric influence*.

RECREATION V.

The marvellous fountain.

SUSPEND a veſſel of water from the middle of the braſs arch, and place in the veſſel a capillary ſyphon. The water will at firſt iſſue by drops only, from the lower leg of the ſyphon, but when the wheel is put in motion, there will be one continued ſtream of water, and if the electrification be ſtrong, a number of ſtreams will iſſue, in form of a cone, the top of which will be at the extremity of the tube. This experiment may be ſtopped and renewed, almoſt inſtantly, at the word of command.

This Recreation may be diverſified by having one of thoſe fountains that are made by condenſed air, as will be deſcribed under the article of Hydraulics: the fountain is to be inſulated, when it will pour forth one ſtream only, but on being electrified, that one ſtream will be divided into a thouſand, and diſperſed over a large ſpace of ground. You may here command either the ſingle, or the divided ſtream, at pleaſure, by only laying your finger on the arch, or taking it off. The ſtreams from both theſe fountains will appear quite luminous in the dark.

RECREA-

* This is an American invention, and was firſt deſcribed by Dr Franklin.

RECREATION VI.

The magic picture.

HAVE a large print, ſuppoſe of the king, with a frame and glaſs*. Cut a pannel out of the print at about two inches from the frame all round; with thin paſte, or gum, fix the border that is cut off, on the inſide of the glaſs, preſſing it ſmooth and cloſe, then fill up the vacancy, by covering the glaſs well with leaf gold, or thin tin-foil, ſo that it may lie cloſe. Cover likewiſe the inner edge of the bottom part of the back of the frame with the ſame tin-foil, and make a communication between that and the tin-foil in the middle of the glaſs; then put in the board, and that ſide is finiſhed. Turn up the glaſs and cover the foreſide with tin-foil, exactly over that on the backſide, and when it is dry, paſte over it the pannel of the print that was cut out, obſerving to bring the correſponding parts of the border and pannel together, ſo that the picture will appear as at firſt, only part of it behind the glaſs, and part before. Laſtly hold the print horizontally by the top, and place a little moveable gilt crown on the king's head†.

Now if the tin-foil on both ſides of the glaſs be moderately electrified, and another perſon take hold of the bottom of the frame with one hand, ſo that his fingers touch the tin-foil, and with the other hand endeavour to take off the crown, he will receive a very ſmart blow, and fail in the attempt. The operator who holds the frame by the upper end, where there is no tin-foil, feels nothing of the ſhock, and can touch the face of the king, without danger, which he pretends to be a teſt of his loyalty. When a ring of perſons take a ſhock among them, the experiment is called the conſpirators.

* This experiment was invented by Mr Kinnerſley, the author of many other improvements in electricity.

† If you have not the figure of a crown, a guinea, or a ſhilling will ſhew the experiment equally well.

RECREATION VII.

The Tantalian cup.

PLACE a cup or pot, of any ſort of metal, on a ſtool of baked wood, or a cake of wax. Fill to the brim with any ſort of liquor; let it communicate with the branch by a ſmall chain, and when it is moderately electrified, deſire a perſon to taſte the liquor, without touching the cup with his hands, and he will immediately receive a ſhock at his lips; which, however, ſhould not be very ſtrong.

The motion of the wheel being ſtopped, you offer to taſte the liquor yourſelf, and deſire the reſt of the company to taſte it likewiſe, which they will do without any inconvenience. You then give the ſignal to the operator, and while you are amuſing the company with diſcourſe, the cup is again charged, and you deſire the ſame perſon a ſecond time to taſte the liquor, when, to the no ſmall diverſion of the company, he will receive a ſecond ſhock.

RECREATION VIII.

The circular chimes.

LET a ſmall upright ſhaft of wood paſs at right angles, through a thin round board, of about twelve inches diameter, and let the ſhaft turn on a ſharp point of iron fixed in the lower end; while a ſtrong wire in the upper end, paſſing through a ſmall hole in a thin braſs plate, keeps the ſhaft truly vertical. About 30 radii, of equal length, made of faſh glaſs, cut in narrow ſlips, are to iſſue horizontally from the circumference of the board; the ends moſt diſtant from the center being about four inches aſunder, and on the end of every one of them is fixed a braſs thimble. If a wire fixed to either of the links at *e* or *f* (Plate III. Fig. 3.) while the other end of the chain communicates with the wire of a bottle electrified in the common way, be brought near the circumference of the wheel, it will attract

attract the nearest thimble, and so put the wheel in motion. That thimble, in passing by receives a spark, and being thereby electrified, is repelled, and so driven forward, while a second thimble, being attracted, approaches the wire, receives a spark, and is driven after the first, and so on, till the wheel has gone once round; when the thimbles before electrified approaching the wire, instead of being attracted as they were at first, they are repelled, and the motion presently ceases.

But if a wire communicating with the other chain, that is connected with another bottle charged through the coating, be brought near the same wheel, it will attract the thimble repelled by the first, and thereby double the force that carries the wheel round; and not only taking out the fire that had been communicated by the thimbles to the first wire, but even robbing them of their natural quantity; instead of being repelled when they come again toward the first wire, they are most strongly attracted; so that the wheel mends its pace, till it goes with great rapidity, twelve or fifteen rounds in a minute, and with such strength, that the weight of four or five pounds, when laid on it, does not visibly retard its motion*.

Now if a radius of baked wood, of about eight inches, be fixed in the upper shaft, and a number of small bells, corresponding to the notes of a tune, be placed on pillars, and fixed in two semicircular stands, at a

 proper

* This part of the machine is sometimes called an electrical jack: for if a large fowl be spitted on the upper shaft, it will be carried round with a motion fit for roasting; and it appears from one of Dr Franklin's letters, that it has been actually applied to this purpose. "In the year 1748, the hot weather coming on, when electrical experiments were not so agreeable, we put an end to them for that season, says the doctor, somewhat humorously, in a party of pleasure on the banks of Skulykil. First, spirits were fired by a spark sent from side to side through the river without any other conductor than the water. A turkey was killed for our dinner by an electrical shock, and roasted by the electrical jack, before a fire kindled by the electrical bottle; and the healths of all the famous electricians in England, Holland, France, and Germany, were drank in electrified bumpers, under a discharge of guns from the electrical battery." Franklin's Letters, p. 35.

proper diſtance from the thimbles, when the wheel turns round the radius will ſtrike againſt the bells, and conſequently play the tune; and as the celerity of the wheel is continually altering, ſo will be the time, or duration of the notes. It is to be obſerved, that the two ſemicircles in which the bells are fixed, muſt not be brought within reach of the radius till the wheel has acquired a conſiderable velocity, for otherwiſe they will at leaſt check, if not totally ſtop its motion. If the ſtroke of the wooden radius do not give a tone ſufficiently acute, a piece of ſolid glaſs may be fixed to the end of it.

If a greater variety of tones is required, there may be two ſets of bells, one for the treble and the other for the baſs. The bells may likewiſe be made to take out of the ſtand, ſo as to perform different tunes by being placed in different poſitions.

RECREATION IX.

The ſelf-moving wheel.

THIS wheel, though conſtructed on the ſame principles with the foregoing, appears ſtill more ſurpriſing. It is formed of a thin round plate of window-glaſs, 17 inches diameter, well gilt on both ſides, all but two inches next the edge. Two ſmall hemiſpheres of wood are then fixed with cement to the middle of the upper and under ſides, centrally oppoſite, and in each of them a thick ſtrong wire, eight or ten inches long, which together make the axis of the wheel. It turns horizontally, on a point at the lower end of its axis, which reſts on a bit of braſs cemented within a glaſs ſalt-cellar. The upper end of its axis paſſes through a hole in a thin braſs plate, cemented to a long and ſtrong piece of glaſs, which keeps it ſix or eight inches diſtant from any non-electric, and has a ſmall ball of wax or metal on the top, to keep in the fire.

In a circle on the table which ſupports the wheel, are fixed twelve ſmall pillars of glaſs, at about eleven inches diſtance, with a thimble on the top of each. On the

the edge of the wheel is a ſmall leaden bullet, communicating by a wire with the gilding of the upper ſurface of the wheel; and about ſix inches from it is another bullet, communicating, in like manner, with the under ſurface. When the wheel is to be charged by the upper ſurface, a communication muſt be made from the under ſurface to the table.

When it is well charged it begins to move. The bullet neareſt to a pillar moves towards the thimble on that pillar, and paſſing by, electrifies it, and then puſhes itſelf from it. The ſucceeding bullet, which communicates with the other ſurface of the glaſs, more ſtrongly attracts that thimble, on account of it being electrified by the other bullet, and thus the wheel increaſes its motion, till it is regulated by the reſiſtance of the air. It will go half an hour, and make, one minute with another, 20 turns in a minute, which is 600 turns in the whole. The bullet of the upper ſurface gives in each turn 12 ſparks to the thimbles, which makes 7200 ſparks; and the bullet of the under ſurface receives as many from the thimbles, thoſe bullets moving in the ſame time 2500 feet. The thimbles are well fixed, and in ſo exact a circle, that the bullets may paſs within a very ſmall diſtance of them.

If inſtead of two bullets, you put eight, four communicating with the upper ſurface, and four with the under ſurface, placed alternately (which eight, at about ſix inches diſtance, complete the circumference), the force and celerity will be greatly increaſed; the wheel making 50 turns in a minute: but then it will not continue ſo long in motion.

RECREATION X.

The magician's chace.

ON the top of a finely painted wire, riſing perpendicularly from the conductor, let another wire, ſharpened at each end, be made to move freely, as on a center. If it be well balanced, and the points be bent horizontally,

rizontally, in oppoſite directions, it will, when electrified, turn very ſwiftly round, by the reaction of the air againſt the current which flows from off the points. Theſe points may be nearly concealed, and the figures of men and horſes, with hounds and a hare or fox, may be placed upon the wires ſo as to turn round with them, when they will look as if the one purſued the other.* If the number of wires proceeding from the ſame center be increaſed, and a ſtill greater variety of wires proceeding from the ſame center be increaſed, and a ſtill greater variety of figures be put upon them, the chace muſt be more diverſified and entertaining. If the wire which ſupports the figures have another wire finely pointed, riſing from its center, a ſecond ſet of wires, furniſhed with another ſort of figures, may be made to revolve above the former, and either in the ſame or the contrary direction, as the operator ſhall think fit.

If ſuch a wire, pointed at each end, and the ends bent in oppoſite directions, be furniſhed like a dipping needle, with a ſmall axis fixed in its middle, at right angles with the bending of the points, and the ſame be placed between two inſulated wire ſtrings, near and parallel to each other, ſo that it may turn on its axis, freely upon and between them, it will, when electrified, have a progreſſive as well as circular motion, from one end of the wires that ſupport it to the other; and this even up a conſiderable aſcent.

RECREATION XI.

The planetarium.

FROM the branch ſuſpend ſix concentric hoops of metal, at different diſtances from each other; and under them, on a ſtand, place a metal plate, at the diſtance of about half an inch. Then place upon the plate,

* This is alſo an invention of Mr Kinnerſley, and is called by him, when the figures of horſes only are uſed, the electrical horſe-race.

plate, within each hoop, and near to it, a round glaſs bubble, blown very light; theſe bubbles and the diſtances between the hoops ſhould correſpond to the different diameters of the planets, and thoſe of their orbits; but as that cannot be on account of the vaſt diſproportion between them, it muſt ſuffice here to make a difference that bears ſome relation to them.

Now the hoops being electrified, the bubbles placed upon the plate, near the hoops, will be immediately attracted by them; in conſequence of which, that part of a bubble which touches a hoop will acquire ſome electric virtue, and be repelled: the electricity not being diffuſed over the whole ſurface of the glaſs, another part of the ſurface will be attracted, while the former goes to diſcharge its electricity upon the plate. This will produce a revolution of the bubble quite round the hoop, as long as the electrification is continued, and will be either way, juſt as the bubble happens to ſet out, or is driven by the operator. A ball hung over the center of all the hoops will ſerve to repreſent the ſun in the center of its ſyſtem. If the room be darkened the ſeveral glaſs balls will appear beautifully illuminated. This experiment affords a remarkable inſtance of electric attraction and repulſion.

RECREATION XII.

The incendiaries.

LET a perſon ſtand upon a ſtool made of baked wood, or upon a cake of wax, and hold a chain communicating with the branch. Upon turning the wheel he will ſoon be electrified; his whole body, in reality, making a part of the prime conductor, and will exhibit the ſame appearances; emitting ſparks wherever he is touched by any perſon ſtanding on the floor. If the prime conductor be very large, the ſparks may be rather painful than agreeable; but if it be ſmall, the electrification moderate, and none of the company touch the eyes, or the more tender parts of the face, the experiment is diverting enough to all parties.

Many

Many of the preceding experiments may be alſo performed to advantage by a perſon ſtanding upon the ſtool as above, and holding in his hand what was directed to be faſtened to the prime conductor. If he hold a large plumy feather in his hand, it is very pleaſing to obſerve how it becomes turgid, its fibres extending themſelves in all directions from the rib; and how it ſhrinks like the ſenſitive plants, when any unelectrified body touches it; when the point of a needle is preſented to it, or to the prime conductor with which he is connected.

If a diſh, containing ſpirits of wine made warm, be brought to the electrified perſon, and be directed to put his finger, or a rod of iron into it, the ſpirit will be immediately in a blaze; and if there be a wick or thread in the ſpirit, that communicates with a train of gunpowder, he may be made to blow up a magazine, or ſet a city on fire with a piece of cold iron; and at the ſame time know nothing of what he is about.

A recreation of this ſort may be performed by ſeveral perſons, that all ſtand upon inſulated ſtools, and many diverting circumſtances may be added to thoſe here mentioned. Care ſhould be taken that the floor on which the ſtools ſtand be free from duſt, but it is moſt eligible to have a large ſmooth board for that purpoſe.

RECREATION XIII.

The inconceivable ſhock.

PUT into a perſon's hand a wire that is fixed on to the hook that comes from the chain which communicates with one ſide of the battery, and in his other hand put a wire with a hook at the end of it, which you direct him to fix on to the hook that comes from the other chain, which when he attempts he will inſtantly receive a ſhock through his body, without being able to gueſs from whence it proceeds. The ſhock will be in proportion to the number of jars that are charged; but it is remarkable, that a ſmall ſhock gives a much-

a much more pungent ſenſation in paſſing through the body, than one that is large.*

This recreation may be diverſified, and rendered ſtill more entertaining, by concealing the chain that communicates with that which comes from the outſide of the battery, under a carpet, and placing the wire that communicates with the chain which comes from the inſide, in ſuch manner that a perſon ſhall put his hand upon it without ſuſpicion, at the ſame time that his feet are upon the other wire. Many other methods of giving a ſhock by ſurprize may be eaſily contrived; but great care ſhould be taken that theſe ſhocks be not too ſtrong, and that they be not given to all perſons indiſcriminately.

When a ſingle perſon receives a ſhock, the company is diverted at his ſole expence; but all contribute their ſhare to the entertainment, and all partake of it alike, when the whole company forms a circle, by joining their hands, and when the operator directs the perſon who is at one extremity of the circle to hold the chain which communicates with the coating, while he who is at the other extremity of the circle touches the other chain or wire. All the perſons who form this circuit being ſtruck at the ſame time, and with the ſame degree of force, it is often very pleaſant to ſee them all ſtart at the ſame moment, to hear them compare their ſenſations, and obſerve the very different accounts they give†.

This experiment may be agreeably varied, if the operator, inſtead of making the company join hands, directs them to tread on each other's toes, or lay their hands

* The ſhock may be made to paſs through any particular part of the body, without much affecting the reſt, if that part, and no other, be brought into the circuit through which the fire muſt paſs from one ſide of the jar or battery to the other.

† M. Monnier of Paris is ſaid to have communicated this ſhock through a line of men, and other conductors, of 900 toiſes, that is, more than an Engliſh mile; and Abbe Nollet performed the ſame experiment upon 200 perſons, ranged in two parallel ranks. Our countryman Mr Walker has electrified two regiments of ſoldiers at once.

hands on each other's heads. If in the latter caſe the whole company ſhould be ſtruck to the ground, as it once happened when Dr Franklin gave the ſhock to ſix very ſtout men, the inconvenience ariſing from it will be very little; the company that was ſtruck in this manner neither heard nor felt the ſtroke, and immediately got up again, without knowing what had happened. This ſtroke was given with two large jars, each of the meaſure of about ſix gallons, but not fully charged.

RECREATION XIV.

Magical exploſions.

WE have ſhown in a preceding recreation how gunpowder may be fired by the intervention of ſpirits, but there is another method, more ſimple and expeditious, which we ſhall here deſcribe. Make up gunpowder in the form of a ſmall cartridge, in each end of which put a blunt wire, ſo that the ends within the cartridge may be about half an inch diſtant from each other, then joining the chain that comes from one ſide of the battery to one of the wires at the end of the cartridge, bring the chain that comes from the other ſide of the battery, to the wire at the other end, when the ſhock will inſtantly paſs through the powder, and ſet it on fire.

By a ſimilar method fine braſs or iron wire may be melted; for the exploſion will paſs from one chain to the other, through the wire, which will be firſt red hot, and then melt into round drops.* A battery of 35 jars has entirely deſtroyed fine braſs wire, of the 530th part of an inch in diameter, ſo that no particle of it could be found after the exploſion. At the moment of the ſtroke, a great number of ſparks, like thoſe from a flint and ſteel, flew upward and laterally from the

* The power of a battery to melt wire is different at different diſtances. Dr Prieſtley found that he could melt nine inches of ſmall iron wire at the diſtance of 15 yards, but at 20 yards diſtance he could only make ſix inches red hot.

the place where the wire was laid, and loſt their light, in the day, at the diſtance of about two or three inches*.

A ſtroke from a common jar will eaſily ſtrike a hole through a thick cover of a book, or many folds of paper, leaving a remarkable bur or prominence on both ſides, as if the fire had darted both ways from the center.

RECREATION XV.

The priſmatic colours†.

TO the ends of each of the chains that come from the battery, fix an iron wire, and between thoſe wires place a plate of tin, of about three inches ſquare, and poliſhed on one ſide‡, in a perpendicular direction. The wire next the poliſhed ſide ſhould be finely pointed, and brought very near the ſurface of the plate.

By repeating the exploſions of the battery, there will firſt appear a duſky red, about the edge of the central ſpot; preſently after, generally after four or five ſtrokes, there appears a circular ſpace, viſible only in an oblique poſition to the light, and looking like a ſhade on the plate: this expands very little during the whole courſe of the exploſions. After a few more diſcharges, the ſecond circular ſpace is marked, by another ſhade beyond the firſt, of one-eighth or one-tenth of an inch in width, which never changes its appearance after any number of exploſions. All the colours make their firſt appearance about the edge of the circular ſpot; more exploſions

* The late Mr Canton, by whoſe ingenuity and induſtry this branch of philoſophy received very great improvement, clearly proved, that pure gold and ſilver might be calcined by the electric exploſion, and be converted into nnmberleſs globules of glaſs, ſome of which were tranſparent, and others tinged with a great variety of colours.

† Th's diſcovery was made by Dr Prieſtley, and ſerves to confirm the Newtonian doctrine of the difference of colours in bodies ariſing from the different denſities of the fine plates that compoſe the ſurfaces.

‡ The poliſh is not neceſſary, but the colours appear more beautiful than on a rough ſurface. This experiment may be made equally well with the other metals, as gold, ſilver, copper, braſs, iron or lead.

exploſions make them expand toward the extremity of the ſpace firſt marked out; while others ſucceed in their place, till after 30 or 40 exploſions, three diſtinct rings appear, each conſiſting of all the colours in the priſm or rainbow.

It makes no difference whether the electricity iſſue from the pointed wire upon the plate, or from the plate upon the pointed wire, the ſurface oppoſite the point being marked exactly the ſame in both caſes. The points themſelves, from which the fire iſſues, or at which it enters, are coloured for about half an inch to a conſiderable degree, and the colours are repeated, as on the plate.

The innermoſt, that is, the laſt formed colours, on the plate, are always the moſt vivid, and thoſe rings are alſo cloſer to each other than the reſt. Theſe colours may be bruſhed with a feather or the finger without injury, but they are eaſily peeled off by the nail, or any thing that is ſharp.

RECREATION XVI.

The artificial earthquake.

IN the middle of a large baſon of water place a round wet board: this board repreſents the earth, and the water the ſea. On the board erect an edifice, compoſed of ſeveral ſeparate pieces, which may repreſent a church, a caſtle, a palace, or if you pleaſe all of them.

Then placing a wire that communicates with the two chains of the battery, ſo that it may paſs over the board and the ſurface of the water, upon making the exploſion the water will become agitated, as in an earthquake, and the board moving up and down, will overturn the ſtructures it ſupports; at the ſame time that the cauſe of this commotion is totally concealed.

This experiment likewiſe was invented by Dr Prieſtley, and when well executed, cannot fail to give great ſurpriſe as well as entertainment.

RECREATION

RECREATION XVII.

*The electrical kite.**

TAKE a large thin ſilk handkerchief, and extend it, by faſtening the four corners to two ſlight ſtrips of cedar. The handkerchief thus prepared and accommodated with a tail, loop and ſtring, will riſe in the air as a common paper kite. To the top of the upright ſtick of the croſs is to be fixed a pretty ſharp-pointed wire, riſing a foot or more above the wood. To the end of the twine next the hand is to be tied a ſilk ribband, and where the twine and ſilk join, a key or tin tube may be faſtened.

This kite is to be raiſed when a thunder guſt appears to be coming on, and as ſoon as the thunder clouds come over the kite, the pointed wire will draw the electricity from them, and the kite, with all the twine, will be electrified, the looſe filaments of the twine will ſtand out every way, and be attracted by the finger. When the rain has wetted the kite and twine, ſo that it can conduct the electric fire freely, it will ſtream out plentifully from the key, on the approach of a man's knuckle. At this key a phial may be charged, and from the electric fire thus obtained, ſpirits may be kindled, and all the other experiments performed.

The greateſt quantity of electricity that was ever brought from the clouds by an apparatus, was by M. de Romas, of Nerac, in the South of France. This gentleman was the firſt who made uſe of a wire interwoven in the hempen cord of an electric kite, which was ſeven feet and a half high, and three feet wide, ſo that it contained 18 ſquare feet of ſurface. This cord was found to conduct the electricity of the clouds more powerfully than a hempen cord, even though it was wetted; and being terminated by a cord of dry ſilk, it enabled the obſerver (by a proper management of his apparatus) to make whatever experiments he thought proper, without danger.

* This is an invention of Dr Franklin.

By the help of this kite, on the 7th of June, 1753, about one in the afternoon, when it was raiſed 550 feet from the ground, and had taken 780 feet of ſtring, making an angle of near 45 degrees with the horizon, he drew ſparks from his conductor three inches long, and a quarter of an inch thick, the ſnapping of which was heard 200 paces.* While he was taking theſe ſparks, he felt as it were, a ſort of cobweb on his face, though he was more than three feet from the ſtring of the kite: after which he did not think it ſafe to ſtand ſo near, and called aloud to all the company to retire, as he did himſelf about two feet.

Thinking himſelf now ſecure enough, and not being incommoded by any body very near him, he took notice of what paſſed among the clouds that were immediately over the kite. There was no appearance of lightning there, or any where elſe, nor ſcarce the leaſt noiſe of thunder, and no rain at all. There was a pretty ſtrong wind at weſt, which raiſed the kite at leaſt 100 feet higher than in any other experiment. Caſting his eyes afterwards on the tin tube faſtened to the ſtring of the kite, and about three feet from the ground he ſaw three ſtraws, one of which was about a foot long, a ſecond four or five inches, and the third three or four inches, all ſtanding erect, and performing a circular dance, like puppets, under the tin tube, without touching each other.

This little ſpectacle, with which ſeveral of the company were much delighted, laſted about a quarter of an hour; after which ſome drops of rain falling, he again perceived the ſenſation of the cobweb on his face, and at the ſame time heard a continual ruſtling noiſe, like that of a ſmall forge bellows. This was a farther warning of the increaſe of electricity, and from the firſt inſtant M. De Romas perceived the dancing ſtraws, he thought it not adviſable to take any more ſparks, even with all his precautions; and he again intreated the company to retire to a ſtill greater diſtance. Im-

* That is, being the half way between the horizon and the point directly over the ſpectator's head.

Immediately after this came on the laſt act of the entertainment, which M. De Romas acknowledges made him tremble. The longeſt ſtraw was attracted by the tin tube, upon which there followed three exploſions, the ſound of which greatly reſembled that of thunder. Some of the company compared it to the exploſion of rockets, and others to the violent craſhing of large earthen jars againſt a pavement. It is certain that it was heard into the heart of the city, notwithſtanding the various noiſes there.

The fire that was ſeen at the inſtant of the exploſion had the ſhape of a ſpindle, eight inches long, and five lines in diameter. But the moſt aſtoniſhing and diverting circumſtance was produced by the ſtraw, which had occaſioned the exploſion, following the ſtring of the kite. Some of the company ſaw it at 45 or 50 fathoms diſtance, attracted and repelled alternately, with this remarkable circumſtance, that every time it was attracted by the ſtring, flaſhes of fire were ſeen, and cracks were heard, though not ſo loud as at the time of the former exploſion.

It is remarkable, that from the time of the exploſion, to the end of the experiment, no lightning at all was ſeen, and ſcarce any thunder heard. A ſmell of ſulphur was perceived, much like that of the luminous electric effluvia iſſuing from the end of an electrified bar of metal. Round the ſtring appeared a luminous cylinder of light, three or four inches diameter; and as this was in the day time, M. de Romas did not queſtion but that if it had been in the night, the electric atmoſphere would have appeared to be four or five feet in diameter. An end was put to theſe remarkable experiments, by the wind's ſhifting to the eaſt, and rain mixed with hail, coming on in great plenty.*

* The quantity of electric matter brought by this kite from the clouds at another time is really aſtoniſhing. Auguſt 26, 1756, the ſtreams of fire iſſuing from it were obſerved to be an inch thick, and ten feet long. Theſe amazing flaſhes of lightning, whoſe report was equal to that of a piſtol, and whoſe effect, had any

As the foregoing account might deter ſome perſons from attempting this very entertaining experiment, eſpecially when there is the appearance of an approaching thunder-ſtorm, we ſhall here add an apparatus, invented by Dr Prieſtley, and with which he thinks there can be no great danger in any thunder-ſtorm.

Let the ſtring *a* of a kite (Plate III. Fig. 4.) be wound upon a reel *b*, going through a ſlit in a flat board, faſtened at the top of it; by which more or leſs of the ſtring may be let out at pleaſure. Let the reel be fixed to the top of a tin or copper funnel *c*, and from the funnel let a metal rod *d*, with a large knob, be projected, to ſerve as a conductor. This funnel and reel muſt be ſupported by a ſtaff *e*, the upper end of which, at leaſt, muſt be well baked, and the lower end may be made ſharp, to thruſt into the ground, when the kite is well raiſed.

The ſafety of this apparatus depends on the chain *f*, faſtened to the ſtaff by a hook a little below the funnel, and dragging on the ground; for the redundant lightning will ſtrike from the funnel to the chain, and ſo be conducted as far as is deſired, without touching the perſon who holds the ſtaff.

Sparks may be taken from the conductor of this apparatus with all ſafety, by means of a ſmall rod of baked wood *g*, furniſhed with a ſmall funnel *h*, a braſs rod *i*, and a chain *k*, connected with it, for the lightning which ſtrikes the rod, will paſs by the funnel and the chain, without touching the perſon who holds the rod.

RECREATIONS IN THE DARK CHAMBER.

To exhibit a great number of pleaſing and ſurpriſing recreations in the dark, as well as in the light, is the peculiar property of electricity; for though there are many beautiful experiments performed in the camera

any of them ſtruck on buildings or animal bodies, would perhaps have been equally deſtructive with any mentioned in hiſtory, were ſafely conducted by the cord of the kite to a non-electric body placed near it.

ra obſcura, it is ſtill by the aid of the ſun's rays, or thoſe of a candle or lamp: whereas the electric apparatus contains within itſelf thoſe particles of fire by which thefe recreations are performed.

RECREATION XVIII.

The miraculous luminaries.

TO perform this recreation it is neceſſary to be provided with a quantity of the following phoſphorus. Calcine common oyſter-ſhells by burning them in the fire about half an hour; then beat them into powder, of the cleareſt of which take three parts, and of flowers of ſulphur one part, and put the mixture into a crucible about an inch and a half deep. Let it burn in a ſtrong open fire for a full hour; when cool, turn it out, and break it into ſeveral pieces, and taking thoſe pieces into a dark place, ſcrape off the brighteſt parts for uſe, which, when good, will be a white powder.

Then take a circular board of three or four feet diameter, on the center of which draw the figure of the half moon, of three or four inches diameter, and round it, at different diſtances, draw a number of ſtars, of different magnitudes. On each of theſe figures fix the phoſphorus juſt mentioned, to the thickneſs of about a quarter of an inch. The board being thus prepared, you muſt have ready a number of charged jars or phials, and by diſcharging one of them, at the diſtance of about an inch, over each figure, it will become illuminated. The light of the creſcent will be ſo ſtrong at firſt, that you may diſtinguiſh by it the figures on the dial of a watch. Round the board let there be placed a rim or hoop, and over that, at a ſufficient diſtance from the figures draw a curtain.

The board thus prepared is to be brought into the darkened room, and placed, by hooks, againſt the ceiling. The curtain is then to be drawn back, and the moon and ſtars will then appear as emerging from behind a cloud, and will continue to ſhine for half an

hour: the light, however, growing continually more faint.

Previous to the performing the following recreation, it will be neceſſary to have a globe and cuſhion placed on the middle of the table, which muſt communicate, by a ſtring that goes through the partition, with the wheel in the other room.

RECREATION XIX.

The globular fires.

LET the room, and all the parts of the apparatus, be made very dry, and let the globe be ſtrongly excited, ſo that the electricity may be very vigorous; the fire will then be ſeen to dart from the cuſhion toward the wire of the conductor. Sometimes theſe lucid rays (which are in part viſible in day-light) will make the circuit of half the globe, and reach the wires; and they will frequently come in a conſiderable number, at the ſame time, from different parts of the cuſhion, and reach within an inch or two of the wires. The noiſe attending this beautiful phenomenon exactly reſembles the crackling of bay leaves in the fire. Theſe lucid arches have frequently radiant points, often four or five in different parts of the ſame arch. Theſe radiant points are intenſely bright, and appear very beautiful. It is peculiarly pleaſing to obſerve the circles of fire riſe from thoſe parts of the cuſhion, where the amalgam or moiſture has been put, or which have been lately ſcraped. Single points on the rubber will then appear intenſely bright, and for a long time together will ſeem to pour out continual torrents of flame. If one part of the rubber be preſſed cloſer than another, the circles will iſſue from that part more frequently than from any other.

When the conductor is taken quite away, circles of fire will appear on both ſides the rubber, which will ſometimes meet and compleatly encircle the globe. If in that ſtate a finger be brought within half an inch of the globe, it is ſure to be ſtruck very ſmartly; and there

there will often be a complete arch of fire from it to the rubber, though it be almoſt quite round the globe.

If all the air be exhauſted from the globe, the electricity will be found to act wholly within it, where it will appear in the form of a cloud or flame of reddiſh or purple-coloured light, filling the whole interior ſpace of the globe*.

RECREATION XX.

The luminous ſhower.

ON the plate at *n*, Plate II. put a number of ſeeds of any kind; or grains of ſand, or a quantity of braſs duſt. The conductor being ſtrongly electrified, thoſe light particles will be attracted and repelled by the plate *o*, ſuſpended from the conductor, with amazing rapidity, ſo as to exhibit a perfect luminous ſhower.

Another method of repreſenting luminous rain, is by a ſpunge that has been immerſed in water. When this ſpunge is firſt hung to the conductor, the water will drop from it very ſlowly; but when it is electrified, the drops will fall very faſt, and will appear like globules of fire, illuminating the baſon into which they fall.

RECREATION XXI.

The illuminated vacuum.

TAKE a tall receiver that is very dry, and through the top of it fix, with cement, a wire, not very acutely pointed. Then exhauſt the receiver, and preſent the knob of the wire to the conductor, and every ſpark will paſs through the vacuum, in a broad ſtream of light, viſible through the whole length of the receiver, how tall ſoever it be. This ſtream often divides itſelf into a variety of beautiful rivulets, which are continually changing their courſe, uniting and dividing again in a moſt

* When this recreation is finiſhed, the globe and rubber muſt be taken away, that they may not incommode the apparatus of the following experiments.

moſt pleaſing manner. If a jar be diſcharged through this vacuum, it gives the appearance of a very denſe body of fire, darting directly through the center of the vacuum, without ever touching the ſides; whereas, when a ſingle ſpark paſſes through, it generally goes more or leſs to the ſide, and a finger put to the outſide of the glaſs, will draw it wherever a perſon pleaſe. If the veſſel be graſped by both hands, every ſpark is felt, like the pulſation of a large artery, and all the fire makes towards the hands. This pulſation is felt at ſome diſtance from the receiver, and a light is ſeen between the hands and the glaſs.

All this while the pointed wire is ſuppoſed to be electrified poſitively; if it be electrified negatively the appearance is remarkably different. Inſtead of ſtreams of fire, nothing is ſeen but one uniform luminous appearance, like a white cloud, or the milky way in a clear ſtar-light night. It ſeldom reaches the whole length of the veſſel, but generally appears only at the end of the wire, like a lucid ball.

If in the neck of a tall receiver a ſmall phial be inſerted, ſo that the external ſurface of the glaſs may be expoſed to the vacuum, it will produce a very beautiful appearance. The phial muſt be coated on the inſide, and while it is charging, at every ſpark taken from the conductor into the inſide, a flaſh of light is ſeen to dart, at the ſame time from every part of the external ſurface of the phial, ſo as to quite fill the receiver. Upon making the diſcharge, the light is ſeen to return in a much cloſer body, the whole coming out at once.

RECREATION XXII.

*The luminous cylinder**.

PROVIDE a glaſs cylinder three feet long and three inches diameter: near the bottom of it fix a braſs plate, and have another braſs plate ſo contrived that you may let

* This is an invention of Dr Watſon.

let it down the cylinder, and bring it as near the firſt plate as you deſire. Let this cylinder be exhauſted and inſulated, and when the upper part is electrified, the electric matter will paſs from one plate to the other, when they are at the greateſt diſtance from each other the cylinder will admit. The braſs plate at the bottom of the cylinder will moreover be as ſtrongly electrified, as if it was connected by a wire with the prime conductor.

The electric matter in its paſſage through this vacuum is ſaid to produce a delightful ſpectacle; not making, as in the open air, ſmall bruſhes or pencils of rays, an inch or two in length, but coruſcations of the whole length of the tube, and of a bright ſilver hue. Theſe do not immediately diverge as in the open air, but frequently form a baſe that is apparently flat, dividing themſelves into leſs and leſs ramifications, and very much reſemble the moſt lively coruſcations of the aurora borealis.

RECREATION XXIII.

The magical conſtellations.

AS the moon and ſtars in the zenith will become dull during the time of performing the preceding recreations, it will be proper to draw the curtain gently before them, that it may ſeem as if a cloud came ſlowly over them; and then the operator may, by his magical power, light up other conſtellations. In order to which, he muſt provide a large board, on which let him mark the ſtars that are in two or more conſtellations, which are contiguous and viſible in the northern hemiſphere, as Taurus, Gemini, &c.

To repreſent theſe ſtars, let there be a hole on each ſide of the ſpot that is marked for a ſtar, about a quarter of an inch diſtant from each other, and let the extremities of two wires, neatly rounded, come through theſe holes, and be brought near together, exactly over the mark. Theſe wires ſhould be of different ſizes, that

that they may the better repreſent the different magnitudes of the ſtars.

The other ends of the wires muſt be ſo diſpoſed, that they may all receive a ſpark from the conductor at the ſame time, and the ſtars will then be all luminous at the ſame inſtant. Theſe ſtars are not evaneſcent, like thoſe made by the phoſphorus, but will continue with equal ſplendor as long as the motion of the wheel is continued. After the ſame manner any cypher, or the outlines of a drawing may be exhibited.

RECREATION XXIV.

The luminous characters.*

PROVIDE a board about four inches wide, as AB, (Plate IV. Fig. 1.) and of what length you pleaſe. On this board place ten or twelve rows of tin-foil, at about half an inch diſtance from each other, and that all communicate together. From theſe lines are to be cut out the characters you intend to repreſent; obſerving that the ends of the tin-foil where it is cut, ſhould not be ſtrait, but pointed as in the figure.

At the beginning of the tin foil there muſt be a braſs knob C, which being brought to the conductor, receives the electricity and conveys it to the tin-foil, over which it would run imperceptibly, were there no breaks in the lines, but being there interrupted, it jumps from one point to the other, making at the ſame time a lucid ſpot, by which the characters are formed, and will continue as long as the wheel is in motion. If at the ſame time the knob is applied to the conductor, the operator place his finger againſt the other end of the uppermoſt line of the tin-foil, and draw it ſlowly down, over the ends of the other lines, it will ſeem as if the characters were formed by the motion of his hand.

This experiment may be made by the diſcharge of a jar or phial, but it will then be of a ſhort continuance.

By

* This is an invention of Mr Henly, the author of the graduated electrometer deſcribed in the apparatus.

Fig. 1.

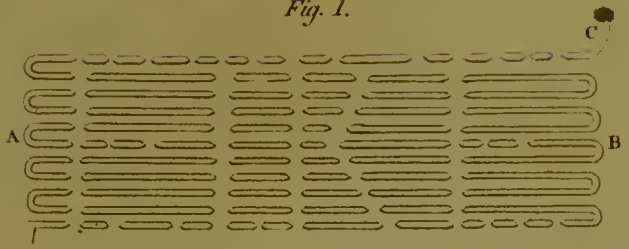
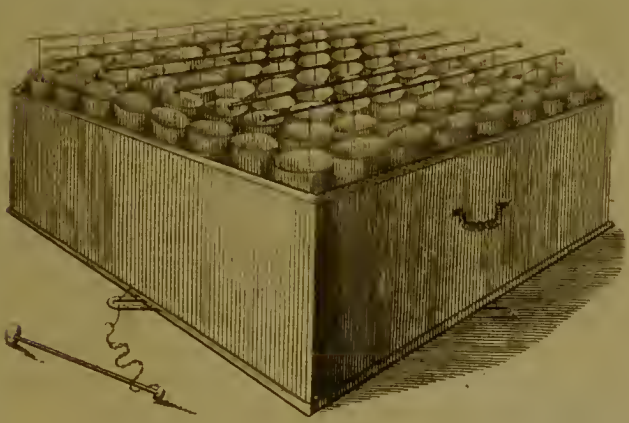


Fig. 2.



By this method alſo the conſtellations, or the outlines of a drawing, &c. may be repreſented.

RECREATION XXV.

*Priſmatic illumination**.

TAKE a glaſs veſſel about a foot long and eight inches diameter, open at both ends; and let one of its ends be cloſed by a braſs ferule, which is to conſtitute one of the centers on which it is to turn: the other end muſt be cloſed with a metal plate: In the center of the plate let there be a ſquare ſtem, which is to be applied to the arbor of a lathe, by which the globe is to be turned round. On one ſide of this laſt plate muſt be fixed a cork, by means of which the glaſs is ſcrewed upon the air-pump.

Upon rarefying the air within the glaſs about 500 times, and afterwards turning the glaſs in the lathe and rubbing in at the ſame time with the hand, a conſiderable quantity of lambent flame, variegated with all the colours of the rainbow, will appear within the glaſs under the hand. This light is perpetually changing colour under the hand, but in every other reſpect it is pretty ſteady.

When a little air is let into the glaſs, the light appears more vivid, and in greater quantity, but is not ſo ſteady, for it will frequently break out in a kind of coruſcation, like lightning, and fly all over the interior part of the glaſs. When a little more air is let in the flaſhing is continual, and ſtreams of bluiſh light ſeem to iſſue from under the hand, within the glaſs, in a thouſand forms, with great rapidity, and appear like a caſcade of fire. Sometimes it is ſeen to ſhoot out into the form of trees, moſs, &c.

When more air is let in, the quantity of light is diminiſhed, and the ſtreams that compoſe the flaſhes narrower. The glaſs now requires greater velocity and harder friction. Theſe circumſtances will increaſe as

* This experiment was made by Mr Smeaton, the inventor of the new air-pump.

as ſtill more air is let in, ſo that by the time the glaſs is one-third full of air, the coruſcations quite vaniſh, and a much ſmaller quantity of light appears partly within, and partly without the glaſs. When all the air is let in, the light appears wholly without the glaſs and much leſs in quantity than when the glaſs is only in part exhauſted.

RECREATION XXVI.

*The aurora borealis**.

MAKE a Torricellian vacuum in a glaſs tube, about three feet long, and ſeal it hermetically†: it will then be always ready for uſe. Let one end of this tube be held in the hand, and the other applied to the conductor, and immediately the whole tube will be illuminated from end to end: and when taken from the conductor will continue luminous, without interruption, for a conſiderable time, very often above a quarter of an hour. If after this, it be drawn through the hand either way, the light will be uncommonly intenſe, and without the leaſt interruption, from one hand to the other, even to its whole length. After this operation, which diſcharges it in a great meaſure, it will ſtill flaſh at intervals, though it be held only at one extremity, and quite ſtill; but if it be graſped by the other hand at the ſame time, in a different place, ſtrong flaſhes of light will hardly ever fail to dart from one end to the other; and this will continue 24 hours, and perhaps much longer; without freſh excitation. Small and long glaſs tubes exhauſted of air, and bent in many irregular crooks and angles, will when properly electrified, beautifully repreſent flaſhes of lightning.

RECREATION

* This is one of the inventions of that great benefactor to this ſcience, Mr Canton.

† The Torricellian vacuum is made by filling a tube with pure mercury, and then inverting it, in the ſame manner as in making a barometer; for as the mercury runs out, all the ſpace above will be a true vacuum. A glaſs is hermetically ſealed by holding the end of it in the flame of a candle, till it is ready to melt, and then twiſting it together with a pair of pincers.

RECREATION XXVII.

The circulating lamps.

AFTER keeping the company thus long in the dark, it will be proper to illuminate the room before you diſmiſs them. In order to which introduce the circulating wheel mentioned in the 9th Recreation. To the upper axis of which let there be fixed a number of radii, made of baked wood, at the end of each of which muſt hang a ſmall globular lamp, filled with ſpirits; and let that of each lamp be tinged with a different colour. The wheel, having previouſly acquired its greateſt velocity, is to be placed on the table, and a chain, depending from the branch, is to dip into each lamp as it paſſes by; ſo that all of them will become illuminated in a very ſhort time. Theſe lamps will not only enlighten the room, but by their variegated colours, and continual revolution, afford a very pleaſing phenomenon.

MAGNETISM.

DEFINITIONS.

1. MAGNETISM is the ſcience that explains the ſeveral properties of the attractive and repellent powers in the magnet or loadſtone.

2. The magnet is a rich, heavy, iron ore of a hard ſubſtance, a duſky grey colour, with ſome mixture of a reddiſh brown, and ſparkling when broke.

3. The magnetic virtue is called the third ſpecies of attraction; gravity being the firſt, and electricity the ſecond.

4. The two ends of a magnet, when it is properly formed, are called its poles; and when it is placed on a pivot, in juſt equilibrium, one end will turn toward the north, and is called its north pole, and the other end the ſouth pole*.

5. When the two poles of a magnet are ſurrounded with plates of ſteel, it is ſaid to be armed.

6. If the end of a ſmall iron bar be rubbed againſt one of the poles of a magnet, it is ſaid to be touched, and is then called an artificial magnet.

7. If ſuch a magnet be ſupported on a pivot, it is called a magnetic needle; one end of it turning toward the north, and the other toward the ſouth.

8. The difference between the poſition of the needle, and the exact points of north and ſouth, is called its declination.

9. A needle which is touched will incline toward the earth, and that is called its inclination or dipping.

APHORISMS.

1. The magnetic attraction is produced by effluvia emitted

* The poles of a magnet are found by holding a very fine ſhort needle over it; for where the poles are, the needle will ſtand upright, but nowhere elſe. The exterior parts are then to be filed or ground off, and the two extremities which contain the poles, to be made quite ſmooth.

emitted by the magnet, and paſſing from one pole to the other*.

2. One pole of a magnet will attract iron, and the other repel it, but no other body†.

The magnet attracts iron as well in vacuo, as in the air.

4. The magnetic attraction will be continued through ſeveral pieces of iron placed contiguous to each other.

5. The magnetic effluvia pervades all bodies.

6. The magnetic attraction extends to a conſiderable diſtance‡.

7. The north pole of one magnet will attract the ſouth pole of another: and the ſimilar poles will repel each other§.

* The direction of the magnetic effluvia is ſhown by the following experiment. Let A B, C D, (Plate VI. Fig. 1.) be the poles of a magnet. Round every ſide lightly ſtrew ſteel filings, on a ſheet of white paper; the particles of the filings will be ſo affected by the effluvia of the ſtone, as to ſhow the courſe they take every way. In the middle of each pole, between AB and CD, they appear to proceed in lines nearly ſtraight; toward the ends they are more and more curved, till at laſt the lines from both ſides, coinciding with each other, form numberleſs curves round the ſtone, which are nearly of a circular figure, as in the plate. This experiment ſeems to ſhew that the magnetic effluvia iſſuing from one pole, circulates to the other.

† The property of the magnet to attract iron has been known many ages: but thoſe of its polar direction, and of its communicating that property to iron, was not diſcovered till the 14th century.

‡ The learned Muſchenbroek made a number of experiments, with great care and aſſiduity, to determine the extent and progreſs of the magnetic attraction, but was never able to diſcover any regular proportion between the force and diſtance; but merely that the force increaſed as the iron approached the magnet. Nor does there ſeem to be any proſpect of eſtabliſhing the proportion of attraction to the diſtance, till a method is found, if it can be found, of ſeparating the attracting from the repelling parts. A needle has been known to be attracted by an iron bar at the diſtance of eight or ten feet.

§ If a magnet be gently cut through the middle of its axis, each piece becomes a complete magnet; for the parts that were contiguous become poles, and even oppoſite poles. So that the end of each piece may become a north or ſouth pole according as the ſection is made neareſt to the north or ſouth pole of the large magnet. Upon cutting a magnet longitudinally, there will be four poles, in the ſame poſition as before the cutting. Sometimes a ſtrong

8. The end of a needle touched by the north pole of a magnet will turn fouth, and that touched by the fouth pole will turn north.

9. The declination of the magnetic needle is different in different parts of the earth, and in the fame part at different times*.

10. The inclination of the needle is not always the fame in different places, nor in the fame place at different times†.

11. The ftrength of natural magnets differs in thofe of different magnitudes, but not in proportion to their magnitudes‡.

12. The ftrength of a natural magnet is confiderably increafed by its being armed§.

13. Iron

ftrong ftroke with a hammer will bring all the magnetic power from one end of a needle to the other; fometimes make it more ftrong where it was before, and at other times totally deftroy it.

* The declination of the needle at London, in the year 1580, was 11 degrees 15 minutes eaft. In the year 1657, there was no declination, that is, the needle ftood exactly north and fouth. At prefent, the declination is more than 22 degrees weftward.

† The inclination of the needle when it was firft obferved, in the year 1576, was found to be 71 degrees 50 minutes: at prefent it is between 74 and 75 degrees.

To prevent the dipping of the needle in the common compafs, the end that is not touched is made fomething heavier, by which it is kept in equilibrio. Under the equator the needle has no inclination, being equally attracted by the two poles of the earth.

‡ The fmalleft magnets have generally the greateft power, in proportion to their bulk. A large magnet will feldom take up more than three or four times its own weight; whereas a fmall one will frequently take up more than ten times its weight. A magnet that weighs fcarce three grains, and that a gentleman wears in his ring, will take up 746 grains, or 250 times its own weight. A magnetic bar made by Mr Canton, according to the method we fhall hereafter defcribe, and that weighed 10 ounces 12 pennyweights, took up fomething more than 79 ounces; and a flat femicircular ftcel magnet that weighed an ounce and 13 pennyweights, lifted an iron wedge of 90 ounces.

§ There are various ways of arming magnets; the moft eligible feems to be that of placing two pieces of ftcel againft the two poles, fo that they may come down below the bottom of the ftone, and binding them on with one or more pieces of brafs; the two ends of the ftcel pieces then become the poles of the magnet. To determine the quantity of ftcel to be applied, try the magnet with

feveral

13. Iron acquires a magnetic power by being continually rubbed in the ſame direction*.

14. Iron bars become magnetic by ſtanding a long time nearly upright†.

15. The magnetic virtue may be communicated by electricity‡.

16. A ſtrong blow at the end of a magnetic bar will give it a magnetic power§.

17. Fire totally deſtroys the power of magnets, as well natural as artificial.

ſeveral ſteel bars, and the greateſt weight it takes up, with a bar on, is to be the weight of its armour.

Though an armed magnet have a great degree of force, it may be eaſily counteracted. If an oblong piece of iron be ſuſpended by one of its poles, and the pole of a different denomination of a weaker and unarmed magnet be placed under the iron, it will quit the firſt magnet and adhere to the other. In like manner when a needle hangs by its point to a magnet, if a common bar of iron be applied to the head of the needle, it will directly quit the magnet and adhere to the bar: but if it hang by its head to the magnet, neither the iron, nor a weak magnet, will diſengage it. Though the pole of an armed magnet have great power, yet if an iron bar of great length be placed under it, the magnet will not appear to have any force whatever.

If a magnet, by lying a long time unuſed, have loſt part of its power, it may ſometimes be recovered. An armed magnet that weighed 14 ounces and a half, and would take up 16 times its own weight, by lying by ſome years loſt one-fourth part of its power. But as much weight being applied to it, as it would then take up, and being ſuffered to hang to it ſome weeks, it would then take up an additional quantity; and the quantity being continually increaſed, at different periods, for the ſpace of two years, it would then take up more than 20 pounds; whereas, before its virtue was impaired, it would not take up 15.

* From hence files, augurs, and ſuch like tools, have always ſome magnetic power.

† Therefore pokers, tongs, and other irons, that always ſtand with the ſame end downward, are conſtantly magnetic; and the continual friction they receive, in keeping them clean, contributes much to this. Some bars acquire ſeveral magnetic poles, alternately North and South.

‡ When the electric ſhock is very ſtrong it will give a polarity to needles; and ſometimes it will reverſe their poles.

§ If ſuch a bar or a pair of pincers, be ſtruck hard, or thrown forcibly againſt a ſtone floor, they will manifeſtly attract a ſmall needle that floats upon the ſurface of the water in a glaſs.

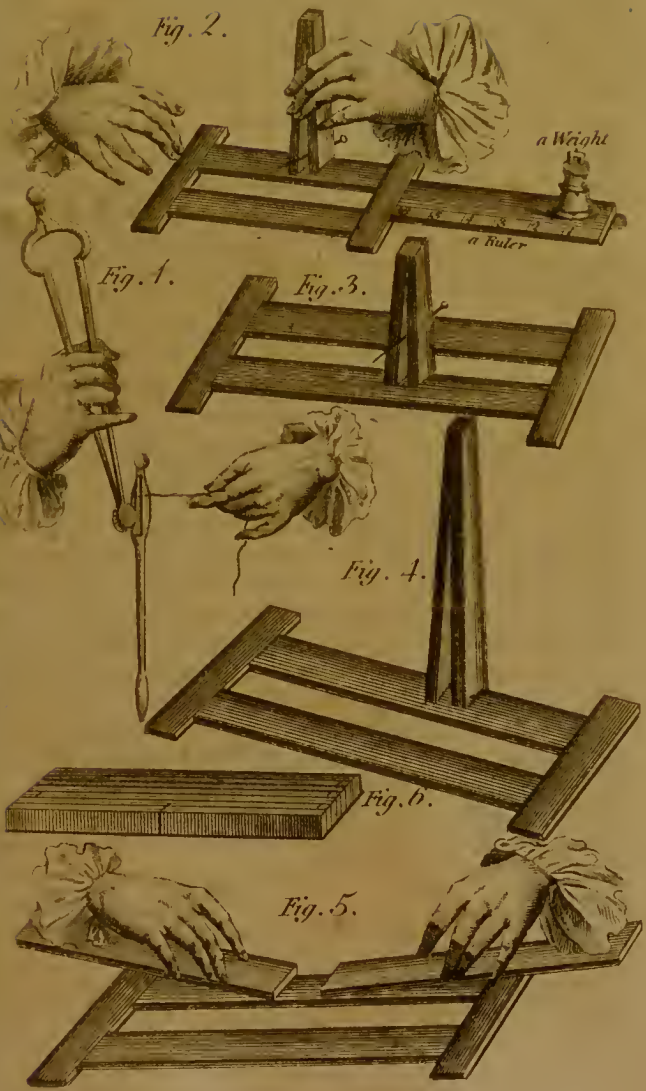
METHOD OF MAKING ARTIFICIAL MAGNETS*.

PROCURE a dozen bars; ſix of ſoft ſteel, each three inches long, one quarter of an inch broad, and one twentieth of an inch thick, with two pieces of iron, each half the length of one of the bars, but of the ſame breadth and thickneſs; and ſix of hard ſteel, each five inches and a half long, half an inch broad, and three twentieths of an inch thick, with two pieces of iron of one half the length, but the ſame breadth and thickneſs as one of the hard bars; and let all the bars be marked with a line quite round them at one end.

Then take an iron poker and tongs (Pl. V. Fig. 1.) the larger they are and the longer they have been uſed, the better; and fixing the poker upright between the knees, hold to it near the top, one of the ſoft bars, having its marked end downward, by a piece of ſewing ſilk, which muſt be pulled tight with the left hand, that the bar may not ſlide: then graſping the tongs with the right hand, a little below the middle, and holding them nearly in a vertical poſition, let the bar be ſtroked, by the lower end, from the bottom to the top, about ten times on each ſide, which will give it a magnetic power ſufficient to lift a ſmall key at the marked end; which end, if the bar was ſuſpended on a point, would turn toward the north, and is therefore called the north pole, and the unmarked end is, for the ſame reaſon called the ſouth pole of the bar.

Four of the ſoft bars being impregnated after this manner, lay the other two (Fig. 2.) parallel to each other, at the diſtance of about a quarter of an inch, between the two pieces of iron belonging to them, a north and a ſouth pole againſt each piece of iron: then take two of the four bars already made mgnetical, and place them together ſo as to make a double bar in thickneſs, the north pole of one even with the ſouth pole

* There are various methods of making theſe magnets: this method is taken from the 47th volume of the Philoſophical Tranſactions, and was invented by the late Mr Canton; to whom the learned world is indebted for many uſeful diſcoveries and improvements in magnetiſm, as well as electricity.


Fig. 2.
a Weight
a Ruler
Fig. 1.
Fig. 3.
Fig. 4.
Fig. 6.
Fig. 5.

pole of the other; and the remaining two being put to theſe in ſuch a manner as to have two north and two ſouth poles together, ſeparate the north from the ſouth poles at one end, by a large pin, and place them perpendicularly with that end downward, on the middle of one of the parallel bars, the two north poles towards its ſouth, and the two ſouth poles towards its north end: ſlide them backward and forward, three or four times, the whole length of the bar; and removing them from the middle of this, place them on the middle of the other bar as before directed, and go over that in the ſame manner: then turn both the bars the other ſide upwards, and repeat the former operation: this being done, take the two from between the pieces of iron, and placing the outermoſt of the touching bars in their room, let the other two be the outermoſt of the four to touch theſe with: and this proceſs being repeated till each pair of bars have been touched three or four times over which will give them a conſiderable magnetic power, but the half dozen together after the manner of the four, Fig. 3, and touch with them two pair of hard bars, placed between their irons, at the diſtance of about half an inch from each other; then lay the ſoft bars aſide, and with the four hard ones let the other two be impregnated, Fig. 4, holding the touching bars apart, at the lower end, near two tenths of an inch, to which diſtance let them be ſeparated, after they are ſet on the parallel bar, and brought together again before they are taken off.

This being obſerved, proceed according to the method deſcribed above till each pair has been touched two or three times over. But as this vertical way of touching a bar will not give it quite ſo much of the magnetic virtue as it will receive, let each pair be now touched once or twice over, in their parallel poſition between the irons, Fig. 5, with two of the bars held horizontally, or nearly ſo; by drawing at the ſame time the north of one from the middle over the ſouth end, and the ſouth of the other from the middle over the north end of a parallel bar: then bringing them

to

to the middle again, without touching the parallel bar, give three or four of these horizontal strokes to each side. The horizontal, touch after the vertical, will make the bars as strong as they can possibly be made: as appears by their not receiving any additional strength, when the vertical touch is given by a great number, and the horizontal, by bars of a superior magnetic power. This whole process may be gone through in about half an hour: and each of the large bars, if well hardened, may be made to lift 28 troy ounces; and sometimes more. And when these bars are thus impregnated, they will give to an hard bar of the same size, its full virtue in less than two minutes; and therefore will answer all the purposes of magnetism in navigation and experimental philosophy, much better than the loadstone, which is well known not to have sufficient power to impregnate hard bars. The half dozen being put into a case, Fig. 6, in such manner, as that two poles of the same denomination may not be together, and their irons with them as one bar, they will retain the virtue they have received. But if their power should, by making experiments, be ever so far impaired, it may be restored without any foreign assistance in a few minutes. And if, out of curiosity, a much larger set of bars should be required, these will communicate to them a sufficient power to proceed with, and they may in a short time, by the same method, be brought to their full strength.

THE MAGNETIC PERSPECTIVE GLASS.

PROVIDE an ivory tube, about two inches and a half long, and of the form expressed in plate VI. Fig. 2. The sides of this tube must be thin enough to admit a considerable quantity of light. It is to open at one end with a screw: at that end there must be placed an eye glass A, Fig. 3, of about two inches focus and at the other end, any glass you please.

Have a small magnetic needle, like that placed on a compass. It must be strongly touched, and so placed at the bottom of the tube that it may turn freely round.

round. It is to be fixed on the center of a ſmall ivory circle C, of the thickneſs of a counter, which is placed on the object-glaſs D, and painted black on the ſide next it. This circle muſt be kept faſt by a circular rim of paſteboard that the needle may not riſe off its pivot, after the ſame manner as is in the compaſs. This tube will thus become a compaſs ſufficiently tranſparent to ſhow the motions of the needle. The eye-glaſs ſerves more clearly to diſtinguiſh the direction of the needle; and the glaſs at the other end, merely to give the tube the appearance of a common perſpective.

It will appear by aphoriſm 8, that the needle in this tube, when placed over, and at a ſmall diſtance from, a magnet, or any machine in which it is contained, will neceſſarily place itſelf in a poſition directed by that magnet, and conſequently ſhow where the north and ſouth pole of it is placed. The north end of the needle conſtantly pointing to the ſouth end of the magnet.

This effect will take place though the magnet be incloſed in a caſe of wood, or even metal, as the magnetic effluvia penetrates all bodies. You muſt obſerve, however, that the attracting magnet muſt not be very far diſtant from the needle, eſpecially if it be ſmall, as in that caſe its influence extends but to a ſhort diſtance.

This tube may be differently conſtructed by placing the needle in a perpendicular direction, on a ſmall axis of iron, on which it muſt turn quite freely, between two ſmall plates of braſs placed on each ſide the tube: the two ends of the needle ſhould be in exact equilibrium. The north and ſouth ends of this needle will, in like manner, be attracted by the ſouth and north ends of the magnetic bar. The former conſtruction, however, appears preferable, as it is more eaſily excited, and the ſituation of the needle much more eaſily diſtinguiſhed.

THE MAGNETIC WAND.

PROCURE a round ſtick of ebony, or other wood, of about eight or ten inches long, and about an inch thick.

thick. Let there be a hole bored through the length of it, of about two or three tenths of an inch in diameter (ſee Pl. VI. Fig. 4.) Provide a ſmall ſteel rod C, and let it be very ſtrongly impregnated by a good magnet. Place this rod in the hollow of the wand, and cloſe it at each extremity, by two ſmall ends of ivory A and B, that ſcrew on, and are differently formed, that you may the more eaſily remember the poles of the magnetic bar.

When you preſent the north pole of this wand to the ſouth pole of a magnetic needle, ſuſpended freely on a pivot, or to a light body ſwimming on the ſurface of water, or any other fluid, and in which you have placed a magnetic bar, that body will then approach the wand, and preſent that ſide which contains the ſouth end of the bar. On the contrary, if you preſent the north or ſouth end of the wand to the north or ſouth end of the needle, or of the bar, they will recede from it.

Obſerve, that after the needle or the floating bar has retired from the wand, it will preſent the other pole to it; therefore as ſoon as the needle retires, you muſt withdraw the wand, or keep it conſtantly preſented to the pole of the ſame name. This wand is of uſe but in very few experiments. To give it more force it may be armed with iron, after the manner explained in the aphoriſms.

RECREATION XXVIII.

The communicative crown.

TAKE a crown piece, and bore a hole in the ſide of it; in which place a piece of wire, or a large needle well poliſhed, and ſtrongly touched with a magnet. Then cloſe the hole with a ſmall piece of pewter, that it may not be perceived. Now the needle in the magnetic perſpective before deſcribed, when it is brought near to this piece of money, will fix itſelf in a direction correſpondent to the wire or needle in that piece.

Deſire

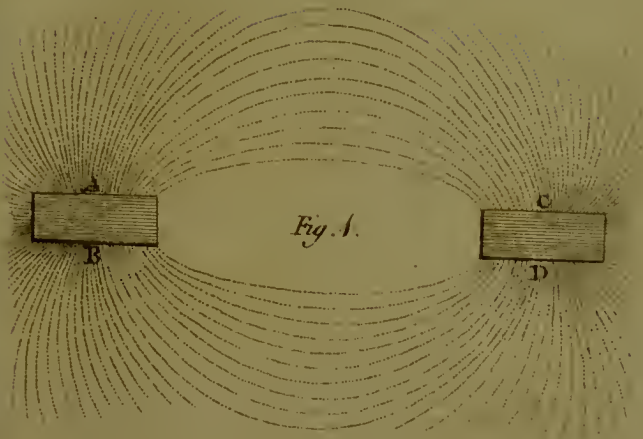


Fig. 1.

Fig. 3.



Fig. 2.



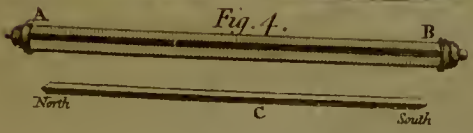


Fig. 4.

Deſire any perſon to lend you a crown piece, which you dextrouſly change for one that you have prepared as above. Then give the latter piece to another perſon, and leave him at liberty either to put it privately in a ſnuff-box, or not; he is then to place the box on a table, and you are to tell him, by means of your glaſs, if the crown is or is not in the box. Then bringing your perſpective cloſe to the box, you will know, by the motion of the needle, whether it be there or not; for as the needle in the perſpective will always keep to the north of itſelf, if you do not perceive it has any motion, you conclude the crown is not in the box. It may happen, however, that the wire in the crown may be placed to the north, in which caſe you will be deceived. Therefore to be ſure of ſucceſs, when you find the needle in the perſpective remain ſtationary, you make ſome pretence to deſire the perſon to move the box into another poſition, by which you will certainly know if the crown piece be there or not.

You muſt remember that the needle in the perſpective muſt here be very ſenſible, as the wire in the crown cannot poſſibly have any great attractive force.

RECREATION XXIX.

The magnetic table.

UNDER the top of a common table place a magnet that turns on a pivot, and fix a board under it, that nothing may appear. There may alſo be a drawer under the table, which you pull out to ſhow that there is nothing concealed. At one end of the table there muſt be a pin that communicates with the magnet, and by which it may be placed in different poſitions: this pin muſt be ſo placed as not to be viſible by the ſpectators. Strew ſome ſteel filings, or very ſmall nails, over that part of the table where the magnet is. Then aſk any one to lend you a knife, or a key, which will then attract part of the nails or filings, in the ſame manner as the iron attracts the needle, in the note to the twelfth aphoriſm. Then placing your hand, in a careleſs

careleſs manner, on the pin at the end of the table, you alter the poſition of the magnet; and giving the key to any perſon you deſire him to make the experiment, which he will then not be able to perform. You then give the key to another perſon, at the ſame time placing the magnet, by means of the pin, in the firſt poſition, when that perſon will immediately perform the experiment.

RECREATION XXX.

The myſterious watch.

YOU deſire any perſon to lend you his watch, and aſk him if he thinks it will or will not go, when it is laid on the table. If he ſay it will, you place it over the end of the magnet, and it will preſently ſtop*. You then mark with chalk, or a pencil, the preciſe point where you placed the watch, and moving the poſition of the magnet, as in the laſt Recreation, you give the watch to another perſon, and deſire him to make the experiment, in which he not ſucceeding, you give it to a third perſon, at the ſame time replacing the magnet, and he will immediately perform the experiment.

RECREATION XXXI.

The bouquets.

IN a box of light wood, that ſhuts with hinges, and is about nine or ten inches long, five or ſix wide, and one inch thick, as ABCD (Pl. VII. Fig. 1.) fix a ſmall vaſe, that has a hole in one ſide, through which is to paſs the end of a bouquet of artificial flowers; of which you are to have two, as F and G. The two principal ſtalks of theſe bouquets are to be made of ſteel, that has been ſtrongly touched; and you are to obſerve that the north pole of one of theſe bouquets is to be placed in the vaſe, and the other is to be at the top of the flower. Both theſe wires, as well as all the o-

others

* To perform this experiment you muſt uſe a ſtrong magnetic bar, and the balance of the watch muſt not be of braſs, but ſteel.

Fig. 1.



Fig. 1.



Fig. 2.

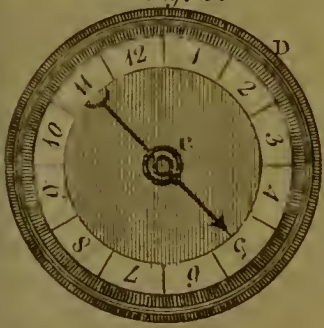


Fig. 4.



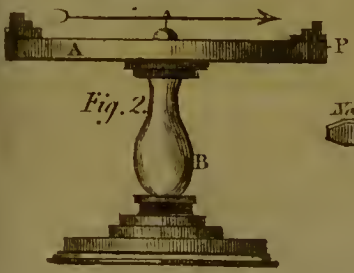


Fig. 2.



Fig. 3.

thers that compoſe the flowers are to be covered with ſilk.

You preſent one of theſe bouquets to any perſon and give him the choice either of placing it privately in the vaſe or not. Then, ſhutting the box, he is to give it you. When applying the magnetic perſpective to it, you diſcover, by the motion of the needle, whether it be there or not; for if it be not there, the needle will not fix itſelf to either end of the box.

You then preſent both the flowers, and give him the choice of placing either of them, in like manner in the box; and by applying the perſpective as before, you diſcover, by the fixing of the needle, which of the bouquets is there placed. You may yet farther diverſify this Recreation by having three flowers, of which one muſt not be impregnated; and give the perſon the choice of placing either of them in the box; but in this caſe he muſt put in one of them.

You muſt obſerve that the needle in the perſpective, in making this experiment, muſt be very ſenſible: it will be proper to try its force on the ſtalk of the bouquet before the flowers are placed on it.

RECREATION XXXII.

The magnetic dial.

PROVIDE a circle of wood or ivory, of about five or ſix inches diameter, as Pl. VII. Fig. 2, which muſt turn quite free on the ſtand B, in the circular border A: on the circle muſt be placed the dial of paſteboard C, whoſe circumference is to be divided into twelve equal parts, in which muſt be inſcribed the numbers from one to twelve, as on a common dial. There muſt be a ſmall groove in the circular frame A, to receive the paſteboard circle; and obſerve that the dial muſt be made to turn ſo free, that it may go round without moving the circular border in which it is placed.

Between the paſteboard circle and the bottom of the frame, place a ſmall artificial magnet E, Fig. 3, that

has a hole in its middle, or a ſmall protuberance. On the outſide of the ſrame place a ſmall pin P, which ſerves to ſhow where the magnetic needle I, that is placed on a pivot at the center of the dial, is to ſtop. This needle muſt turn quite free on its pivot, and its two ſides ſhould be in exact equilibrio.

Then provide a ſmall bag, that has five or ſix diviſions, like a lady's work-bag, but ſmaller. In one of theſe diviſions put ſmall ſquare pieces of paſteboard, on which are wrote the numbers from one to twelve; and if you pleaſe you may put ſeveral of each number. In each of the other diviſions you muſt put twelve or more like pieces, obſerving that all the pieces in each diviſion muſt be marked with the ſame number.

Now the needle being placed upon its pivot, and turned quickly about, it will neceſſarily ſtop at that point where the north end of the magnetic bar is placed: and which you previouſly know by the ſituation of the ſmall pin in the circular border.

You therefore preſent to any perſon that diviſion of the bag which contains the ſeveral pieces on which is wrote the number oppoſite to the north end of the bar, and tell him to draw any one of them he pleaſes. Then placing the needle on the pivot, you turn it quickly about, and it will neceſſarily ſtop, as we have already ſaid, at that particular number.

Another recreation may be made with the ſame dial, by deſiring two perſons to draw each of them, one number out of two different diviſions of the bag, and if their numbers, when added together, exceed twelve, the needle or index will ſtop at the number they exceed it: but if they do not amount to twelve, the index will ſtop at the ſum of thoſe two numbers. In order to perform this recreation you muſt place the pin againſt the number five, if the two numbers to be drawn from the bag be ten and ſeven: or againſt nine, if they be ſeven and two.

If this recreation be made immediately after the former, as it eaſily may, by dextrouſly moving the pin, it will appear ſtill the more extraordinary.

RECREATION

RECREATION XXXIII.

The magnetical cards.

ON the paſteboard circle mentioned in the preceding recreation, inſtead of the twelve numbers, inſcribe the four ſuits of the cards, and the eight cards of each ſuit that are uſed at piquet, in the following order:

Diviſions.

1. Ace
2. King
3. Knave
4. A heart
5. Queen
6. A diamond
7. An eight
8. A ſpade
9. A ten
10. A ſeven
11. A club
12. A nine,

as is expreſſed in Plate VII. Fig 4. You muſt have two ſimilar needles, which however muſt be diſtinguiſhable by ſome private mark. Theſe needles muſt have their oppoſite points touched. Of the eight cards of piquet inſcribed on the circle there are only four that are of uſe here, which are thoſe that are oppoſite the four pips: the others however are uſed in the ſecond part of this recreation.

When you place that needle or index on the pivot whoſe pointed end is touched, it will ſtop at one of the four pips againſt which you have placed the pin in the frame: then taking that needle off, and placing the other, it will ſtop at the oppoſite point.

Therefore deſire a perſon to draw a card from a piquet pack, offering that card againſt which you have placed the pin of the dial, which you may eaſily do by having a long card, as is explained in the firſt volume. Tell the perſon who draws the card to keep it cloſe, that it may not be ſeen. Then give him one of

the two needles, and desire him to place it on the pivot and turn it about, when he will see it stop at the colour of the card he has chose: then taking that needle off, change it dextrously for the other, and give that to another person, telling him to place and turn it in like manner, and it will stop at the name of the card the first person chose.

If the person should not draw the card you intend, you cannot directly perform this recreation: therefore, to prevent any suspicion that you have failed in your design, cut the cards yourself at the long card, and let him put the card he drew under that card, then give them to one or more persons to cut, and when you perceive the long card is at bottom, you tell the person that the card he drew is at the top of the pack: and after this little diversion you may begin the recreation again.

The foregoing recreation may be diversified by having a pack of piquet cards in which there are two longer than the rest, and that answer to two that are opposite each other on the circle, and were not used in the other recreation. Then let two persons draw each of them one of those two cards.

Present the needle that will point to the second person's card to the first person: after which take it off, and changing it privately, present to the second person the needle that will point to the first person's card. You will observe that this recreation does not show the particular suite in which the two cards were drawn.

RECREATION XXXIV.

The dextrous painter.

PROVIDE two small boxes as M and N, (Pl. VIII. Fig. 1.) four inches wide and four inches and a half long. Let the box M be half an inch deep, and N two-thirds of an inch. They must both open with hinges and shut with a clasp. Have four small pieces of light wood, as OPQR in the same plate, of the same size with the inside of the box M, and about one third

Fig. 1.



Fig. 2.

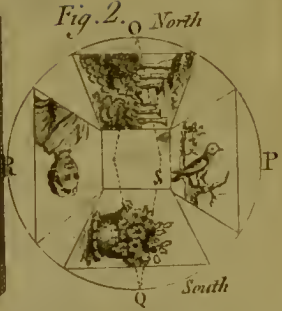
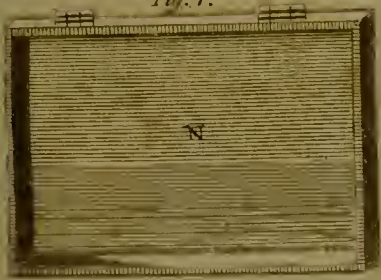
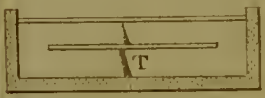


Fig. 1.

















third of an inch thick. In each of these let there be a groove, as AB, EF, CD, GH, these grooves must be in the middle, and parallel to two of the sides. In each of these grooves place a strong artificial magnet as V. The poles of these magnets must be properly disposed with regard to the figures that are to be painted on the boards; as is expressed in the plate. Cover the bars with paper to prevent their being seen; but take care in pasting it on not to wet the bars, as they will thereby rust, which will considerably impair their virtue. When you have painted such subjects as you choose, you may cover them with a very thin clear glass.

At the center of the box N, place a pivot T, on which a small circle of pasteboard OPQR, Fig. 2. is to turn quite free; under which is to be a touched needle S. Divide this circle into four parts, which are to be disposed with regard to the poles of the needle, as is expressed in the figure. In these four divisions you are to paint the same subjects as are on the four boards, but reduced to a smaller compass. Cover the inside of the top of this box with a paper M, (see Fig. 1.) in which must be an opening D, at about half an inch from the center of the box, that you may perceive, successively, the four small pictures on the pasteboard circle just mentioned. This opening is to serve as the cloth on which the little painter is supposed to draw one of the pictures. You may cover the top of the box, if you please, with a thin glass.

Then give the first box to any person, and tell him to place any one of the four pictures in it privately, and when he has closed it, to give it you. You then place the other box over it, when the moveable circle, with the needle, will turn till it comes in the same position with the bar in the first box. It will then appear that the little dextrous painter has already copied the picture that is inclosed in the first box.

RECREATION XXXV.

The cylindric oracle.

PROVIDE a hollow cylinder of about ſix inches high, and three wide, as AB, Pl. IX. Fig. 1. Its cover CD, muſt be made to fix on any way. On one ſide of this box or cylinder let there be a groove EF, nearly of the ſame length with that ſide; in which place a ſmall ſteel bar as H, that is ſtrongly impregnated; with the north pole next the bottom of the cylinder. On the upper ſide or the cover deſcribe a circle, and divide it into ten equal parts, in which are to be wrote the numbers from one to ten, as is expreſſed at G. Place a pivot at the center of this circle, and have ready a magnetic needle. You are then to provide a bag, in which there are ſeveral diviſions, like that deſcribed in the 32d Recreation. In each of theſe diviſions put a number of papers, on which the ſame, or ſimilar queſtions, are wrote.

In the cylinder put ſeveral different anſwers to each queſtion, and ſeal them up in the manner of ſmall letters. On each of theſe letters or anſwers is to be wrote one of the numbers on the dial or circle at the top of the box. You are ſuppoſed to know the number of the anſwers to each queſtion.

You then offer one of the diviſions of the bag obſerving which diviſion it is, to any perſon, and deſire him to draw one of the papers. Next put the top on the cylinder, with that number which is wrote on the anſwer directly over the bar. Then placing the needle on the pivot you turn it briſkly about, and it will naturally ſtop at the number over the bar. You then deſire the perſon who drew the queſtion to obſerve the number at which the needle ſtands, and to ſearch in the box for a paper with the ſame number, which he will find to contain the anſwer.

You may repeat the experiment by offering another diviſion of the bag to the ſame or another perſon: and placing

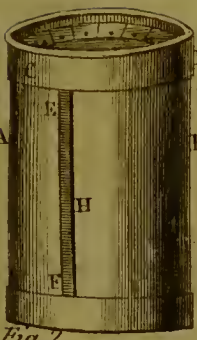
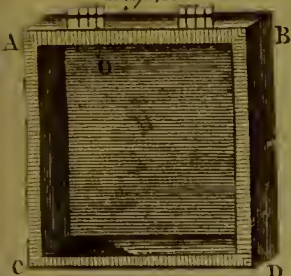


Fig. 1.



Fig. 2.



Number Fig. 4.





Fig. 3.









placing the number that corresponds to the answer over the magnetic bar, proceed as before.

It is easy to conceive of several answers to the same question. For example, suppose the question to be, Is it proper to marry?

Answer 1. While you are young, not yet; when you are old, not at all.

2. Marry in haste and repent at leisure.

3. Yes, if you can get a good fortune; for something has some savour, but nothing has no flavour.

4. No, if you are apt to be out of humour with yourself; for then you will have two persons to quarrel with.

5. Yes, if you are sure to get a good companion; for that is the greatest blessing of life. But take care you are sure.

6. No, if the person you would marry is an angel; unless you would be content to live with a devil.

RECREATION XXXVI.

The mystical dial.

IN a box, ABCD, (Plate IX. Fig. 2.) of about four inches square, and that shuts with a hinge, let there be an opening O, of three inches and a half square, and half an inch deep.

Provide four square pieces of wood E, F, G, H, Fig. 3. of the same size with the opening in the box. On these pieces describe the circles ILMN, which divide into four equal parts by the diagonals IM and LN, and then subdivide the parts NM and IL into four other equal parts: in each square piece make a groove, as P, Q, R, S, and in each groove place a magnetic bar: then cover the squares with paper, and write on them the words two, six, eight, and twelve, as is expressed in the figure.

On another square piece, Fig. 4. of the same size with the surface of the box, describe a circle, and divide it into four equal parts by the diagonals MP and NO: then subdivide each of those four parts into four other equal parts;

parts; forming in the whole ſixteen equal diviſions, in which you are to write the numbers expreſſed in that figure. You will obſerve, that on the ſide MN are wrote the numbers that are in the other four ſquares; on the oppoſite ſide OP, the double of thoſe numbers; on the ſide NP, the half of thoſe numbers; and on the oppoſite ſide MO, the triple of the firſt numbers. Fix a pivot at the center of this circle, and on it place a magnetic needle.

You then give the four ſquare pieces to a perſon and deſire him to put any one of them in the box, then to ſhut it, and place it himſelf on the table. He is next to chooſe whether the index of the dial ſhall point to the number of the ſquare he has placed in the box, its half, its double, or triple; and you then place the dial over the box in the proper poſition. For the north pole of all the bars in the four ſquare pieces being on the ſame ſide, the index will neceſſarily ſtop at that ſide; and conſequently, as the dial is placed, will point to the whole, the half, the double, or triple of each number.

RECREATION XXXVII.

The enchanted ewer.

FIX a common ewer, as A, (Plate X. Fig. 1.) of about twelve inches high, upon a ſquare ſtand BC, in one ſide of which there muſt be a drawer D, of about four inches ſquare and half an inch deep. In the ewer place a hollow tin cone, inverted, as AB, Fig. 2, of about four inches and a half diameter at top, and two inches at bottom; and at the bottom of the ewer there muſt likewiſe be a hole of two inches diameter.

Upon the ſtand, at about an inch diſtance from the bottom of the ewer, place a ſmall convex mirror H, Fig. 2, of ſuch convexity that a perſon's viſage, when viewed in it, at about fifteen inches diſtance, may not appear above two inches and a half long.

Upon the ſtand likewiſe, at the point I. Fig. 2, place a pivot of half an inch high, on which muſt be fixed a

touched

Fig. 1.



Fig. 2.

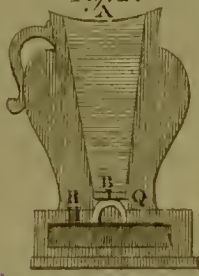


Fig. 3.









Fig. 4.



Fig. 5.

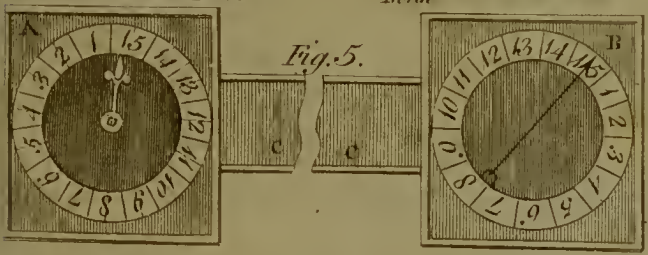
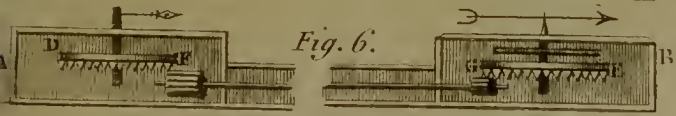


Fig. 6.



touched needle RQ, inclosed in a circle of very thin pasteboard OS, Fig. 3. of five inches diameter. Divide this pasteboard into four parts, in each of which draw a small circle: and in three of these circles paint a head as *x*, *y*, *z*, the dress of each of which, is to be different, one, for example, having a turban, another a wig, and the other a woman's cap. Let that part which contains the face in each picture be cut out: and let the fourth circle be entirely cut out, as it is expressed in the figure. You must observe that the poles of the needle are to be disposed in the same manner as in the plate.

You are next to provide four small frames of wood or pasteboard, *w*, *x*, *y*, *z*, Fig 4. each of the same size with the inside of the drawer. On these frames must be painted the same figures as on the circular pasteboard, with this difference, that there must be no part of them cut out. Behind each of these pictures place a magnetic bar, in the same direction as is expressed in the plate; and cover them over with paper, that they may not be visible.

Matters being thus prepared, you first place in the drawer the frame *w*, on which there is nothing painted. You then pour a small quantity of water into the ewer, and desire the company to look into it, asking them if they see their own figures as they are. Then you take out the frame *w*, and give the three others to any one, desiring him to choose in which of those dresses he would appear. Then put the frame with the dress he has chose in the drawer, and a moment after, the person looking into the ewer will see his own face surrounded with the dress of that picture.

This Recreation, well performed is highly agreeable. As the pasteboard circle can contain only three heads, you may have several such circles, but you must then have several other frames: and the ewer must be made to take off from the stand.

RECRE-

RECREATION XXXVIII.

The magicians circles.

LET there be two boxes, A and B, (Pl. X. Fig. 5.) of about ſix inches ſquare, and connected by the piece C, of one inch and a half wide. The depth of the boxes muſt be one inch, and that of the piece half an inch. In theſe boxes and the piece place the movement AB, Fig. 6, compoſed of two horizontal wheels, D and E, that have the ſame number of teeth, and two pinions F and G. The axis of the wheel D muſt paſs through the top of the box; and on it muſt be placed a hand, by which it may be turned about: but that of E muſt end beneath the cover of the box; a magnetic bar being placed on it, and above the box, on a ſmall pivot, muſt be placed a touched needle. This movement ſhould be ſo contrived as not to make any noiſe by its motion.

Draw a magic ſquare in the following manner, conſiſting of twenty-five leſſer ſquares, numbered; and each line of which whether read horizontally or perpendicularly, contains five words that give an anſwer to a queſtion propoſed. Let the five queſtions be as follows:

	1.	2.	3.	4.	5.
1.	Are	you	pleaſed	with	matrimony?
2.	What	does	all	times	pleaſe?
3.	Should	we	wiſh	for	inheritance?
4.	Do	you	deſire	more	riches?
5.	What	pleaſure	is	moſt	deteſtable?

Then-

Then draw the square thus.

d Magic Square.

1. I love	2. quite	3. well	4. my	5. husband
6. quite	7. pleases	8. what	9. wealth	10. brings
11. well	12. what	13. man	14. craves	15. delights
16. my	17. wealth	18. craves	19. much	20. encreasing
21. husband	22. brings	23. delights	24. encreasing	25. ever

On each side of the boxes place a square pasteboard of the same dimension, and on that of A draw a circle and divide it into thirty equal parts. On that of B, draw likewise a circle, and divide it into fifteen equal parts. In the divisions of the circle A, write the words contained in the first five columns of the following table, which compose the foregoing questions in the order they are numbered. That is, the word *are* in the first division, the word *be* in the second division, the word *you* in the third, the word *what* in the fourth division, &c. On the fifteen divisions of the circle B, write the words in the order they stand in the last column of this table. In the first circle, the words must be wrote from right to left, and in the other from left to right.

Order

Order of placing the words of the queſtions and anſwers on the two circles.

No	1 queſtion	2 queſtion	3 queſtion	4 queſtion	5 queſtion	No.	Anſwers
1	1 are or 2 be	- -	- -	- -	- -	1	I love
2	3 you	4 what	- -	-	- -	2	quite
3	5 content	- -	6 ſhould	- -	- -	4 3	well my
4	7 with	- -	- -	8 do	- -		
5	9 matrimony	- -	- -	- -	10 what	5	huſband
6	- -	10 does or 12 can	- -	- -	- -	6	pleaſes
7	- -	13 all	14 we	-	- -	7	what
8	- -	15 times	- -	16 you		8	wealth
9	- -	17 pleaſe	- -	- -	18 pleaſure	9	brings
10	- -	- -	19 wiſh or 20 pray	- -	- - - -	10	man
11	-	- -	21 for	22 deſire		11	craves
12	- -	- -	23 inheritance	- -	24 is	12	delights
13	- -	- -	- -	25 more or 26 greater	- -	13	much
14	- -	- -	- -	27 riches	28 moſt	14	encreaſing
15	- -	- -	-	- -	29 deſirable or 30 eſtimable	15	ever

The words being thus tranſcribed on the dials, the hands of both of them are to be placed to the correſponding diviſions; for example, when the index of the dial A, is placed to the word *are*, that of the dial B, muſt direct to the diviſion which contains *I love;* and ſo of the reſt. You muſt then write on five cards the five foregoing queſtions, that is, one of them on each card.

Matters being thus prepared, you preſent the five cards to any perſon, and deſire him to chooſe one of them, and then let him direct the index of the firſt dial ſucceſſively to each of the five words which compoſe that queſtion: while another perſon, placed by the dial to which the touched needle is placed writes down the words it ſucceſſively points to, and they will be found to form the anſwer. The moſt remarkable circumſtance in this recreation is, that the fifteen words on the dial B, give proper anſwers to the five queſtions on the other dial, which contain thirty words; and that every anſwer conſiſts of the ſame number of words with the queſtion.

Theſe dials, by means of pullies, may communicate when placed on the oppoſite ſides of a room: and this experiment may be diverſified, by having ſeveral dials to place over the movement, with various words or figures: the foregoing ſerving only as a ſpecimen of the manner of performing recreations of this ſort.

RECREATION XXXIX.

The box and dice.

MAKE a hollow pedeſtal as CA, (Pl. XI. Fig. 1.) twelve inches long, nine wide, and one deep. The cover of this pedeſtal muſt be made to ſlide on and off, and not be above two-tenths of an inch thick. Toward the part A of the cover deſcribe the circle B, which is to be divided into twenty equal parts; and on theſe points mark the different parts that can be

thrown by two dice*. At the center place a pivot, on which a magnetic needle is to turn.

On the bottom of the inside of this pedestal, and directly under the circle at top, describe another circle M, which must be divided and marked in the same manner. At the center fix a magnetic bar by a screw, so that it may be easily placed in any position; but not move of itself.

You must have two needles, the point of one being north and the other south: they should be in appearance quite similar; but there must be, however, some mark by which you can distinguish them.

On the pedestal place a vase DE, of tin or pasteboard, about twelve inches high. In the side of the vase there must be two parts that open, one at FG, and the other at GH. These openings should not be deeper than the depth of one die, nor wider than two; and they must be made to shut quite close, that the places where they open may not appear. The cover of the vase D, must take off. There must be a communication between the top and the division GH, and in that division are to he placed two dice of any number. In that part IK must be placed the slider ST, which is exactly of the same length, and open next S, where must be placed two dice that contain the points at which one of the needles is to stop; and in the division FG, two other dice that are to contain the points at which the other needle is to stop. The bar within the pedestal is supposed to be previously fixed to the points that answer to the dice.

Matters being thus prepared, you open the part GH, and taking out those dice you throw them in at the top, and shew that they will fall into the same place again. You take them out a second time and give them to any person, telling him to throw them in

* The number of different points that can be thrown by two dice is twenty-one, of which there are only twenty here, as the divisions are obliged to be diametrically opposite each other: that number however is quite sufficient for the present purpose.

Fig. 1.

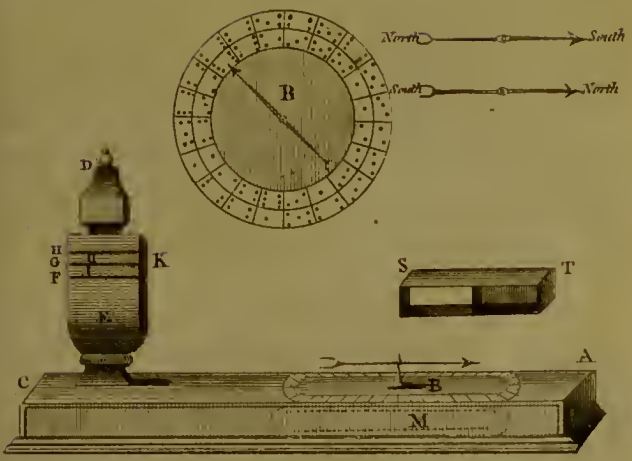


Fig. 2.

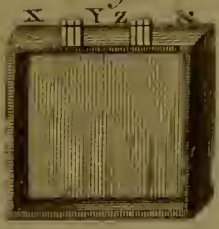


Fig. 3.

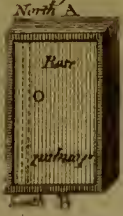
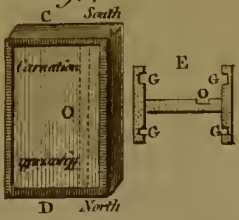
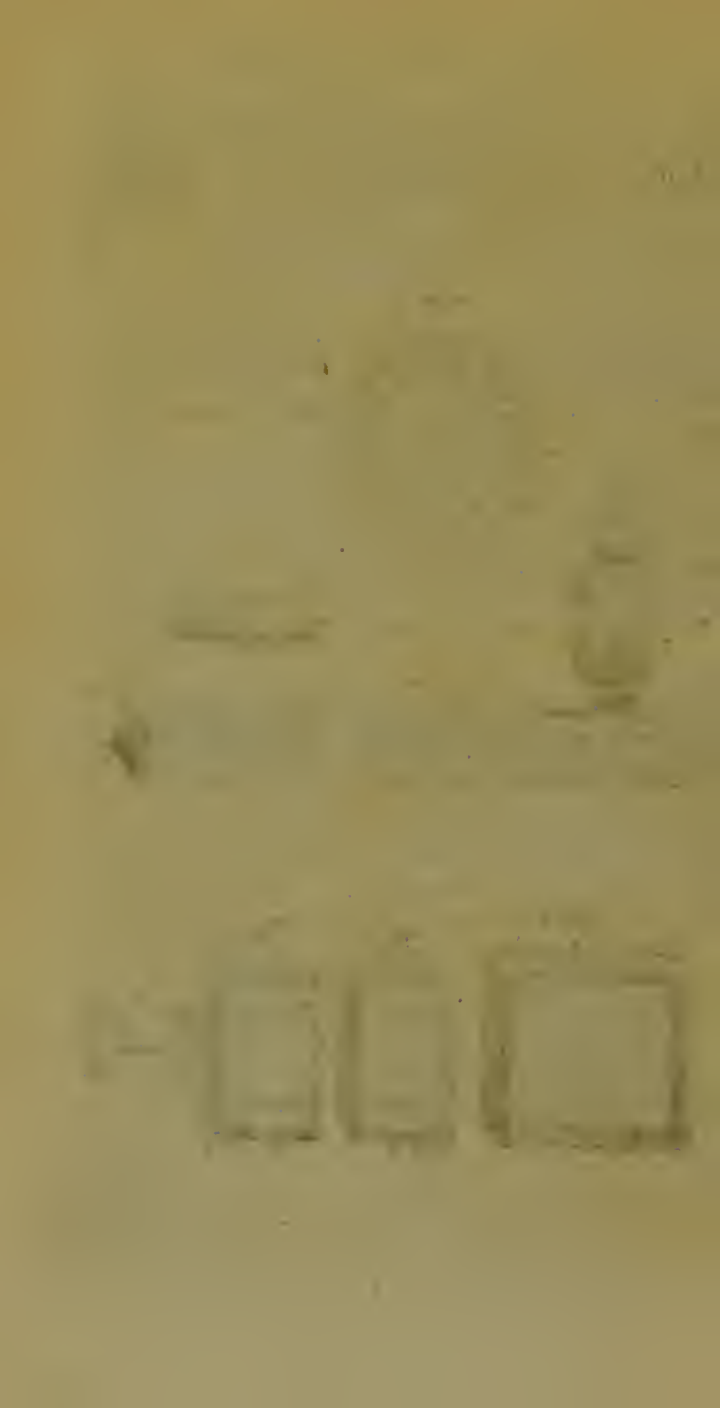


Fig. 4.





in at top. In the mean time you incline the vaſe toward your left hand, when the ſlider at IK will come to GH, and thereby prevent the dice that are thrown in at top from falling into that diviſion by ſtopping up the paſſage. You then preſent him with a proper needle, which he places on the pivot and turns briſkly about, and when it ſtops you tell him that the dice in the vaſe will have the ſame points with that diviſion at which it has ſtopped. Which on your opening the upper diviſion he will find to be true. You then take thoſe dice out, and give them to another perſon: and taking the needle off the pivot dextrouſly change it for the other. You deſire that perſon to throw the dice in at top, and give him the proper needle: and when it ſtops, you open the diviſion FG, and taking out thoſe dice, he will find them alſo anſwer to the points on the diviſion of the circle where the needle ſtopped.

RECREATION XL.

The box of flowers.

PROVIDE a box of light wood, eight inches long, five wide, and one inch and a half deep, (Pl. XI. Fig. 2.) provide alſo two caſes, Fig. 3 and 4, five inches long, four wide, and an inch and a half thick. Theſe muſt be made hollow on each ſide in the manner as is expreſſed in the profile E. In each of them there muſt be a groove that contains a bar O, ſtrongly impregnated: the poles of theſe bars are to be diſpoſed in the manner expreſſed in the figure: toward the part G, there muſt be a ſlider that holds a glaſs, and the ſides of the caſes muſt be cloſed.

In the four hollow parts in theſe two caſes, and under the glaſſes place four ſmall natural flowers, of different ſorts, and let them be in oppoſite directions, that is, the top of one flower to be level with the bottom of that on the other ſide.

In whatever poſition theſe caſes are placed in the box, the poles of the bars next the hinges, will have a determinate direction. If the north pole of the bar

attract the needle in the magnetic perſpective at the point X, it is the roſe that is there placed. If the ſouth attract the needle, it is the jonquil. It will be the ſame when thoſe two poles attract the needle at Z.

If the ſouth pole attract the needle at the point Y, it is the carnation that is there placed. If the north pole attract it there, it is the hyacinth: and it will be the ſame when thoſe two poles attract the needle at &. You muſt remember that the north pole of the bar attracts the ſouth of the needle, and the ſouth the north. You therefore give the two caſes, containing the flowers, to any one, and let him place them, in what poſition he pleaſe, in the box: and then, by the aid of the magnetic perſpective, you tell him immediately where each flower is placed.

RECREATION XLI.

The box of metals.

PROVIDE a wooden box about thirteen inches long and ſeven wide, as ABCD, (Pl XII. Fig. 1.) The cover of this box ſhould be as thin as poſſible.

Have ſix ſmall boxes or tablets, about an inch deep; all of the ſame ſize and form, as EFGHIK, that they may indiſcriminately go into ſimilar holes made in the bottom of the large box.

In each of theſe tablets is to be placed a ſmall magnetic bar, and their poles are to be diſpoſed as is expreſſed in the figure. Cover each of theſe tablets with a thin plate of one of the ſix following metals; viz. gold, ſilver, copper, iron, pewter, and lead. You muſt alſo have a magnetic perſpective, at the end of which is to be two circles, one divided into ſix equal parts, and the other into four, as in Fig. 2. from the center of which there muſt be drawn an index N, whoſe point is to be placed to the north.

Therefore, when you are on the ſide CD of the box, and hold your perſpective over any one of the tablets that are placed on the holes E, F, G, ſo that the index drwn on the circle is perpendicular to the ſide AB,

the

Fig. 1.

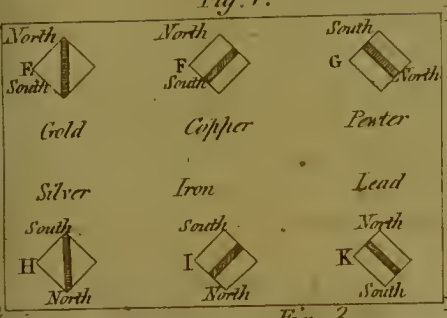


Fig. 2.



Fig. 3.

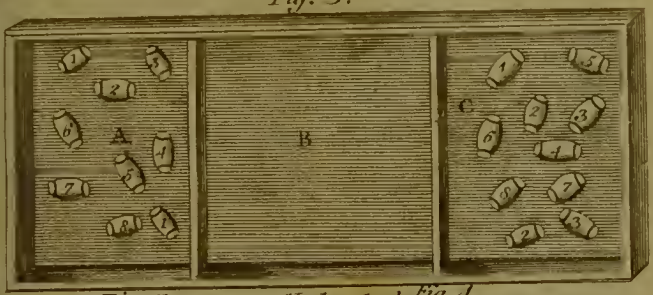


Fig. 5.



Fig. 4.



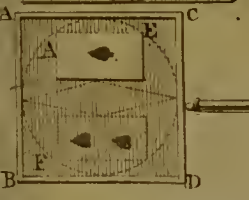
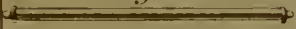
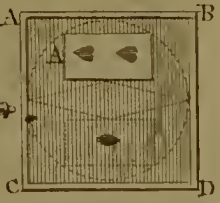


Fig. 6.





the needle in the perſpective will have its ſouth pole directed to the letter that denotes the metal contained in that tablet. When you hold the perſpective over one of the boxes placed in the holes H, I, K, ſo that the index drawn on the circle is perpendicular to the ſide C D, the ſouth pole of the needle will in like manner expreſs the name of the metal incloſed.

If the under-ſide of any one of the tablets be turned upward, the needle will be ſlower in its motion, on account of the greater diſtance of the bar. The gold and ſilver will ſtill have the ſame direction, but the four other metals will be expreſſed by the letters on the interior circle.

If any one of the metals be taken away, the needle will not then take any of the above directions, but naturally point to the north; and its motion will be much ſlower.

You therefore give the box to any one, and leave him at liberty to diſpoſe all the tablets in what manner, and with which ſide upward he pleaſe, and even to take any one of them away. Then by the aid of your perſpective you tell him immediately the name of the metal on each tablet, and of that he has taken away.

This box of metals* will on compariſon, be found far to exceed that which has been publicly exhibited: for that being compoſed of ſix tablets, of which two only differ in form, admits but of ſix different diſpoſitions, whereas in this the tablets may be placed 720 different ways. In the other you muſt alſo know the particular ſide of the box, which in this is not at all neceſſary. Nay, you may here diſtinguiſh each metal, though the box be completely covered with paper; for the effect of the needle will be always the ſame. The recreations with this box are therefore much more extraordinary, and its conſtruction at the ſame time more ſimple.

* It was invented by the Duke de Pequigny, and by him communicated to M. Guyot.

RECREATION XLII.

The magnetic oracle.

IN a box a foot long, three inches and three quarters wide, and one inch deep, make three equal diviſions, A, B, C, (Plate XII. Fig. 3.) Have eight ſmall boxes or tablets of the ſame ſize with the diviſion B of the box, into which they ſhould go only one-fourth of an inch deep. In two of theſe tablets make a groove from the oppoſite angles, going from right to left, in which place the bars A, B, Fig 4. and in two others a groove that goes in like manner from left to right, in which put the bars C, D. In two others a groove that divides them vertically into two equal parts, and place in them the bars E, F: and in the two laſt a groove that divides them horizontally, in which place the bars G, H. The poles of each of theſe bars are to be placed in the manner expreſſed in the figure.

Upon a board five inches ſquare deſcribe the circle NO, (Fig. 5.) which is to be divided into eight equal parts, in each of which write one of the numbers 1, 2, 3, 4, 5, 6, 7, 8, as in the figure, and let this board be placed on the part B of the box ABC.

Provide 32 ſmall rundlets of wood or ivory, of three quarters of an inch long, and pierced with a hole of about one quarter of an inch diameter, Fig 3. and mark theſe barrels with the numbers 1, 2, 3, 4, 5, 6, 7, 8.

Then cover the tablets with paper to conceal the magnetic bars; and on each of them write ſome queſtion, in ſuch manner that the laſt word may direct to the north pole of the bar.

On ſmall ſlips of paper write four different anſwers to each queſtion, then roll them up and put them into the little rundlets. You muſt obſerve that the ſame number is to be wrote on four of the rundlets, and one of the four anſwers put into each of them, according to the direction of the needle of the dial. The

little

little barrels being thus prepared, are to be placed on the two ſides A and C of the box Fig. 3.

You then give the eight tablets to any one, and leave him at liberty to place which of them he pleaſe on the box; which being done he is to turn the index round, and when it ſtops he is to chooſe one of thoſe rundlets that are marked with the number where it ſtops, in which he will neceſſarily find the proper anſwer. To diverſify this Recreation, the favourable anſwers may be placed on one ſide of the box, and the unfavourable on the other, ſo that you may tell him to chooſe either the one or the other.

RECREATION XLIII.

The incomprehenſible card.

INSERT in the middle of a card, and parallel to its two longeſt ſides, part of a watch ſpring, as thin as poſſible, and ſtrongly impregnated: let it be ſo concealed as not to afford the leaſt ſuſpicion. This card ſhould be a little longer than the others of the pack in which it is placed.

Offer any one to draw a card out of the pack, and preſent the long card dextrouſly to his hand. You then give him all the cards, and leave him to replace that card in the pack or not. He is then to lay the pack on the table, and by applying your magnetic perſpective, you will diſcover whether the card be there or not.

If the perſon ſhould not draw that card, you muſt be ready with ſome other recreation, to prevent ſuſpicion of having failed in your deſign.

RECREATION XLIV.

The two magical cards.

PROVIDE a box ABCD (Plate XII. Fig. 6.) four inches ſquare and three quarters of an inch deep. Cover its top with a paſteboard, in which there is an opening at A. At the center of this box let there be

a

a pivot that ſupports a circle of paſteboard EF, on which is painted two cards: and at its center is to be a magnetic needle; as is expreſſed in the figure.

Now if you lay the magnetic wand, deſcribed at page 57, of this volume, ſo that the north pole of the bar it contains be next the middle of one of the ſides of the box, the magnetic needle, with the paſteboard circle, will turn ſo that its ſouth pole will be next the wand. But if the ſouth end of the wand be next the box, the north end of the needle will preſent itſelf, and conſequently one or the other of the cards will be viſible. You muſt therefore have a pack of cards in which one of the ſame ſort with thoſe painted on the circle is a ſmall matter longer, and the other, wider than the reſt.

Being thus prepared, you deſire two perſons to draw each one card, taking care to preſent thoſe two cards ſo artfully that they can ſcarce draw any other. Then holding the wand careleſly in your hand, you aſk one of the parties whether his own or the other perſon's card ſhall appear firſt. You then touch the box with your magic wand, and lay it on the table, as if the more eaſily to open the box. After giving the needle a ſhort time to ſettle, you open the box and ſhew the card deſired. To ſhow the other card, you place the box on the table with the other ſide next the wand.

You may ſhuffle the cards before you offer them, as you will always diſtinguiſh by the touch where the two cards are. If the parties ſhould not draw thoſe two cards, you muſt be ready with ſome other amuſement, that it may not be perceived you have failed.

RECREATION XLV.

The magnetic planetarium.

CONSTRUCT a round box ILMN, of eight or nine inches diameter, and half an inch deep, (Plate XIII. Fig. 1.) On its bottom fix a circle of paſteboard, on which draw the central circle A, and the ſeven circumjacent circles B, C, D, E, F, G, H. Di-

vide

Fig. 1.


I
L
M
N
South
North
Question
January
February
March
April
May
June
July
August
September
October
November
December

Fig. 2.


O
P
Q
R
South
North
North
South



vide the central circle into ſeven equal parts by the lines AB, AC, AD, AE, AF, AG, and AH, which muſt paſs through the centers of the other circles and divide each of them into two equal parts. Then divide the circumference of each of thoſe circles into 14 equal parts, as in the figure.

You are likewiſe to have another paſteboard of the ſame figure, and divided in the ſame manner, which muſt turn freely in the box, by means of an axis placed on a pivot, one end of which is to be fixed in the center of the circle A. See Fig 2.

On each of the ſeven ſmaller circles at the bottom of the box, place a magnetic bar, two inches long, in the ſame direction with the diameters of thoſe circles, and their poles in the ſituations expreſſed in the figure.

There muſt be an index O, like that of the hour-hand of a dial, which is to be fixed on the axis of a central circle, and by which the paſteboard circle in the box may be turned about. There muſt be alſo a needle P, that will turn freely on the axis, without moving the circular paſtcboard.

In each of the ſeven diviſions of the central circle write a different queſtion and in another circle, divided into 12 parts, you may write the names of the 12 months. In each of the ſeven circles write two anſwers to each queſtion, obſerving that there muſt be but ſeven words in each anſwer; in the following manner.

In the firſt diviſion of the circle G, which is oppoſite the firſt queſtion, write the firſt word of the firſt anſwer. In the ſecond diviſion of the next circle write the ſecond word; and ſo on to the laſt word, which will be in the ſeventh diviſion of the ſeventh circle.

In the eighth diviſion of the firſt circle write the firſt word of the ſecond anſwer: in the ninth diviſion of the ſecond circle write the ſecond word of the ſame anſwer; and ſo on to the fourteenth diviſion of the ſeventh circle, which muſt contain the laſt word of that anſwer.

The ſame muſt be done for all the ſeven queſtions, and to each of them muſt be aſſigned two anſwers, the words

words of which are to be diſperſed through the ſeven circles.

At the center of each of theſe circles place a pivot, and have two ſets of magnetic needles as Q R, the pointed end of one ſet being north, and the other ſouth.

Now, the index of the central circle being directed to any one of the queſtions, if you place one of the two magnetic needles on each of the ſeven leſſer circles, they will fix themſelves according to the direction of the bars on the correſponding circles, at the bottom of the box, and conſequently point to the ſeven words that compoſe the anſwer. If you place one of the other needles on each circle, it will point to the words that are diametrically oppoſite to thoſe of the firſt anſwer, the north pole being in the place of the ſouth pole of the other.

You therefore preſent this planetarium to any perſon, and deſire him to chooſe one of the queſtions there wrote; and you then ſet the index of the central circle to that queſtion, and putting one of the needles on each of the ſeven circles, you turn it about, and when they all ſettle they will point to the ſeven words that compoſe the anſwer. The two anſwers may be one favourable and the other unfavourable: and the different needles will ſerve to diverſify the anſwers when you repeat the experiment.

The moveable needle P, is to place againſt the names of the months; and when the party has fixed upon a queſtion, you place that needle againſt the month in which he was born, which will give the buſineſs an air of more myſtery.

At the center of the large circle may be the figure of the ſun, and on each of the ſeven ſmaller circles, one of the characters of the five planets, together with the earth and moon. This Recreation, well executed, is one of the moſt entertaining that magnetiſm has produced.

CONSTRUCTION

Fig. 1.

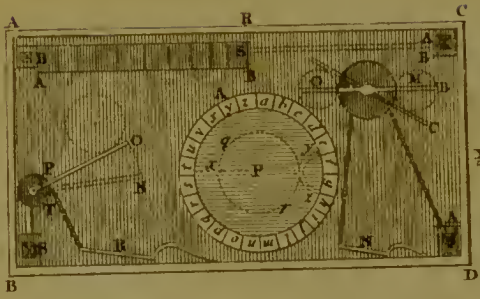


Fig. 3.

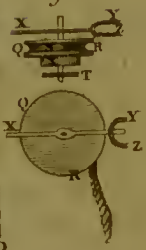


Fig. 2.

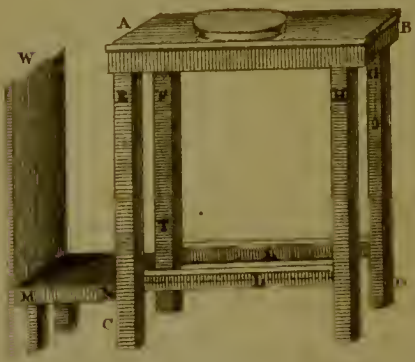


Fig. 4.



Fig. 5.



CONSTRUCTION OF THE MAGNETICAL AND MECHANICAL TABLE.

LET the table ABCD (Plate XIV. Fig. 1, and 2.) be conſtructed by an able workman, as near as poſſible after the following plan and dimenſions.

Firſt, this table muſt be five feet long, by two feet and a half wide. Its top muſt be only half an inch thick, except at the edge, which is to be one inch and a half thick, and go out beyond the feet of the table about an inch. This precaution is quite neceſſary, that the magnetic apparatus concealed beneath the ſurface of the table may be nearer to the pieces placed on it; and that there may be no room to imagine that there are any parts concealed.

Secondly, the four feet E, F, G, H, Fig. 2. as well as the two croſs-pieces L, L, muſt be hollow, being formed of four pieces of wood half an inch thick, and two inches wide, and conſequently the ſpace between them a ſquare inch.

In the third place, there muſt be a ſecond ſurface to the table, placed under the other, and at one inch and a half diſtance from it. Fourthly at one end of the table frame, and parallel with the croſs-pieces L, L, there muſt be a ſtep MN, which joins to the frame; the joints of this ſtep are likewiſe to be hollow and communicate with the two hind feet of the table. This table muſt be made with great care, that there may be no room to ſuſpect there are any cavities in the legs or top; and if any of the jointings ſhould appear, they muſt be painted to prevent all ſuſpicion. The table being thus prepared may be covered with a green cloth, on which are to be placed the different pieces hereafter deſcribed, by which the ſubſequent recreations are to be performed.

On the ſide of the lower plane of the table next AB, at eight inches diſtance from the point O, and at the point P, fix the piece QR, Fig. 3, compoſed of a pulley S, of ſix inches diameter, and one third of an inch thick,

thick, on which is fixed a braſs rod; to one end of which muſt be faſtened two magnetic bars, eight inches long and bound together by four braſs rings; or a ſingle bar, ſtrongly impregnated; or elſe an impregnated horſeſhoe, placed as XYZ.

Beneath this pulley, and at its center, fix the braſs barrel X, of one inch and a half diameter, and half an inch thick, in which fix the ſpring of a clock. At the end of the axis of the pulley, and beyond the braſs barrel, let there be a ſquare hole that is to come out, under the table, and cloſe to it, and by which is to be faſtened a ſmall wheel with a catch, that the ſpring in the barrel may be contracted or extended at pleaſure. Round the pulley let there go a ſmall ſtring, ſuch as is not much apt to dilate or contract*. It ſhould paſs over a ſmall pulley near the opening into the foot H, and then over another at the bottom of the ſame foot†, and oppoſite to the communication with the ſtep, that it may go behind the partition W.

Againſt the other ſide of the partition there is to be placed a table (Plate XV.) of two feet and a half long, and placed at a convenient height for the perſon who is to draw the ſtring that communicates with the magnetic apparatus, clearly to diſtinguiſh the numbers, letters, and words there wrote.

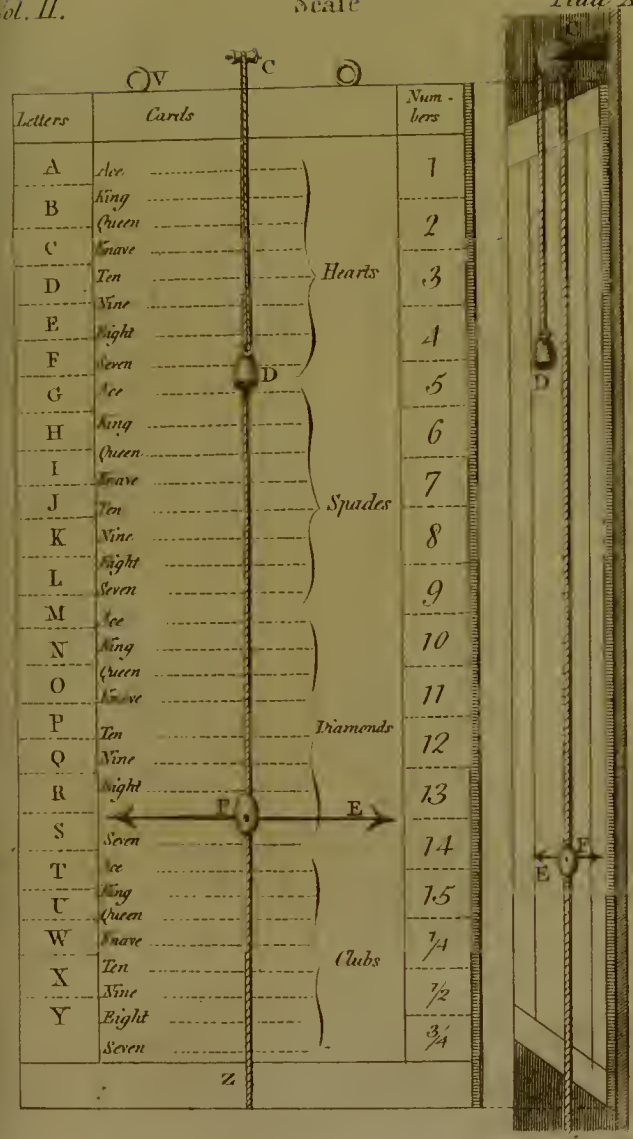
The table is thus formed. Firſt, meaſure the exact diſtance that the cord paſſes over while the pulley makes a complete revolution, and mark that diſtance on the table, as from V to Z.

Have three circles of wood, covered with paper, as A, B, and C, Fig 1, 4, and 5. Divide that of A into 24 equal parts, and in each of thoſe parts write one of the 24 letters of the alphabet. Divide the firſt column of the table into the ſame number of equal parts, and in each of them write the ſame letters and in the ſame order.

Then

* It may be braided like a lace, as that is not much ſubject to contract.

† Theſe pullies ſhould be fixed on their axis, that they may not make any noiſe in turning.


V
C
Letters
Cards
Num-bers
A Ace 1
B King 2
Queen
C Knave
D Ten 3
Nine
E Eight 4
F Seven
Hearts
D
G Ace 5
H King 6
Queen
I Knave
J Ten 7
K Nine 8
L Eight 9
Seven
Spades
M Ace 10
N King
O Queen 11
Knave
P Ten
Q Nine 12
R Eight 13
S Seven 14
T Ace
U King 15
Queen
W Knave
X Ten 1/4
Y Nine 1/2
Eight 3/4
Seven
Diamonds
Clubs
F
E
Z
C
D
E
F

Then divide the circle B into 32 equal parts, in each of which write the name of one of the cards of piquet. Divide the second column of the table in the same number of equal parts, and in them write the same names in the same order.

Lastly divide the circle C, into 18 equal parts, in each of which write one of the numbers from 1 to 15, and the three fractions $\frac{1}{4}$, $\frac{1}{2}$, $\frac{3}{4}$. Then divide the third column of the table into the same number of equal parts, and in them write the same numbers likewise*.

The pulley C must be placed above the table, and over it must run the string, at the end of which is to hang the weight D, sufficiently heavy to keep it distended, but not to put the pulley on the table in motion. To this string must be annexed the wire or index E, which must be moveable, that it may be adapted to the unavoidable contraction or dilation of the string, occasioned by the moisture or dryness of the air; as otherwise it would not constantly answer to the divisions on the board.

Provide a copper bason, quite thin, about a foot in diameter, and one inch and a half deep. It should have two handles, that you may take it readily off the table without spilling the water. This bason is to go into each of the circles described above. Each of those circles also must have a private mark, by which you may place it on the table in its proper position.

Then of very light wood or cork, make a small figure, in the shape of a siren or mermaid, in which is to be placed a magnetic bar, in a proper direction with regard to the magnetic horse-shoe. This figure is to float upon the surface of the water in the bason†.

In the last place, part of the step at the bottom of the frame must be moveable, in the manner of a lever,

* You may have other circles, on which may be wrote the 21 chances on the dice; a number of answers to certain questions, and a great variety of other matters; as every one's fancy will suggest.

† Instead of a siren you may form a small fish of very thin copper, and hollow; or a small boat, or any other figure you please.

and communicate with the other ſide of the partition, ſo as to be viſible to the perſon behind it, but not any one in the room where the machine ſtands.

Now, matters being thus prepared, when you place the baſon on the table in one of the circles, ſo that its center is over the axis that turns the magnetic piece concealed in the table, if the perſon behind the partition draw the index in the ſtring up to any one of the numbers, letters or words on Plate XV. the magnetic piece on the table will place itſelf againſt the ſame number, letter, or word. Therefore, if you place the ſiren on the ſurface of the water, it will, by means of a magnetic wire concealed in it, direct itſelf to that part where the large bar or horſe-ſhoe is moved. If the perſon behind the partition draw the wire up and down, before he fix it, the ſiren will in like manner make various motions, as if undetermined where to fix.

RECREATION XLVI.

To make the ſiren of the magnetic table point to all the letters of a given word.

YOU muſt have three cards, on which are wrote the names of three perſons or cities, or any other words you pleaſe. One of theſe cards muſt be of the common ſize, another a little longer, and the third a little wider. Theſe cards you give to any perſon, and deſire him to chooſe which of them he thinks proper, and to keep it to himſelf. He is then to return you the two remaining cards, and you will diſcover immediately by the touch, which card he has choſe. You are previouſly to agree with the perſon behind the partition on the three different expreſſions, which denote the card that is choſen. For example, you are to ſay either, *The ſiren ſhall name the word*; or *ſhe ſhall point out the letters that compoſe the word*; or *ſhe will find out the word.* Then your confederate, after giving the ſiren ſome indeterminate motions, will direct her ſucceſſively to the ſeveral letters that compoſe the word wrote on the card.

Note,

Note, the confederate muſt be of a ready apprehenſion; and aſſiſt his memory, adjoining to the forementioned table, he ſhould have a paper, on which are wrote the ſeveral ſigns you are to give him.

The ſiren is to point out the time expreſſed by any given watch.

You deſire any perſon to lend you his watch, and laying it on the table, you tell him that the ſiren ſhall ſhow the preciſe time at which it then is. You then mount the ſtep, as if to place the watch more properly; and at the ſame time preſs down the moveable pieces as many times as are equal to the hours. The perſon behind the partition obſerving carefully that number, makes the ſiren point to it. You then make a ſimilar ſignal for the quarters and minutes, and your confederate, in like manner as before, makes the ſiren point reſpectively to them.

To make the ſiren point to three numbers that have been choſen by three different perſons.

You muſt have a ſmall bag, like that deſcribed in the 32d Recreation of this volume in which there are four diviſions. In the firſt of them you muſt put the numbers from 1 to 15; and in each of the three others ſeveral tickets that have the ſame number, but not higher than 15. You draw out a handful of tickets from the firſt diviſion, and ſhow that they conſiſt of different numbers. Then put them again in that diviſion, and offer one of the other diviſions to the three perſons, from which they are each to draw a ſingle number. Your confederate being previouſly informed what thoſe three numbers are, and in what order they are to be drawn, will immediately direct the ſiren to them.

After the parties have drawn the three numbers, you may aſk whether the ſiren ſhall point to their numbers ſeparately, or to the amount of the whole. Suppoſe, for example, the three numbers be 5, 7, and 11. The ſiren is then made to point firſt to 2, and

then to 3, which form 23, the amount of thoſe numbers.

You may likewiſe let the ſame perſon draw two or three numbers, and the ſiren ſhall ſhow him either thoſe numbers ſeparately, their amount, or their product when multiplied together.

A perſon having drawn a card from the pack, the ſiren points to the name of that card on the circle.

The perſon having drawn, from a piquet pack, the card that you have previouſly agreed on with your confederate, by your preſenting that card in the manner already deſcribed, he immediately directs the ſiren to that card. It will be proper to agree on a ſecond card with your confederate, that you may repeat the experiment if it ſhould be deſired.

A queſtion being propoſed by any perſon, the ſiren gives the anſwer; though the perſon who exhibits the Recreation does not know the queſtion.

On five cards write five ſuch different queſtions as may be all anſwered by the ſame word: as for example.

1. What can be in all parts of the earth at the ſame time?

2. What does the ivy round the oak?

3. What muſt a man have to carry him croſs the ocean?

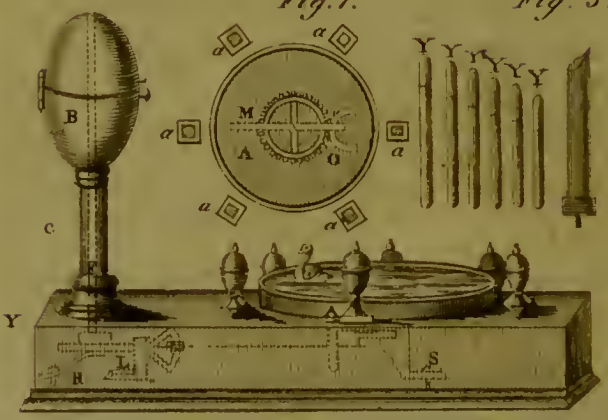
4. What is it the hunter does with his horn?

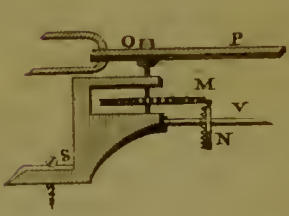
5. What makes a great noiſe but no ſhow?

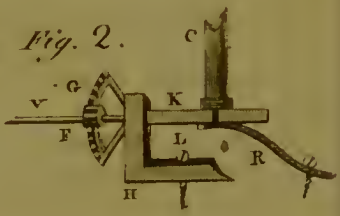
6. What brings trees, towers and ſteeples to the ground?

All theſe queſtions are to be anſwered by the word *wind*. You therefore ſhow that the cards contain different queſtions, and then give them to any perſon, telling him to chooſe one of them privately, and keeping it to himſelf, to put the reſt in his pocket; which being done, your confederate directs the ſiren to the letters that compoſe that word. If you would repeat the experiment, you muſt have another ſet of cards which have a different anſwer, that it may not appear

that


Fig. 1.
Fig. 3.
B
C
M
A
O
a
F
Y
X
R
L
S


O
P
M
V
N
S


Fig. 2.
C
G
V
K
F
L
R
H

that the ſame word anſwers all the cards. This recreation is eaſily performed, and occaſions no ſmall degree of ſurpriſe.

The principal part of theſe recreations with the ſiren were invented by M. Guyot, and were therefore never exhibited in public before the appearance of his book.

RECREATION XLVII.

The ſagacious ſwan.

PROVIDE a box XY, (Pl. XVI. Fig. 1.) eighteen inches long, and nine wide, and two deep, the top of which is to ſlide on and off, at the end Y. Toward the end X, deſcribe a circle of ſix inches diameter, round which are to be fixed ſix ſmall vaſes of wood or ivory, of one inch and a half high; and to each of them there muſt be a cover.

At the end Y place an egg B, of ivory or other matter, of about three inches and a half high, with a cover that ſhuts by a hinge, and faſtens with a ſpring. It muſt be fixed on the ſtand C, through which, as well as the bottom of the egg, and the part of the box directly underneath, there muſt paſs a hole of one-third of an inch in diameter. In this cavity place an ivory cylinder F, that can move freely, and riſes or falls by means of the ſpring R. You muſt have a thin copper baſon A, of ſix inches diameter, which is to be placed on the center of the circle at X, and conſequently in the middle of the ſix vaſes.

Let a proper workman conſtruct the movement expreſſed by Fig. 2. which is compoſed of a quadrant G, that has 16 teeth, and is movcable about an axis in the ſtand H, that has an elbow, by which it is ſcrewed to the bottom of the box at L; and to the quadrant there muſt be joined the ſtrait piece K. The horizontal wheel M, has 24 teeth, and is ſupported by the piece S, which is ſcrewed to the end of the box next X. On the axis of this wheel place a braſs rod OP, five inches long, and at the part O place a large bar or horſe-ſhoe, of a ſemicircular form, and about two

inches and a half diameter, ſtrongly impregnated. The ſteel rod V, takes at one end the teeth of the quadrant G, by the pinion F, and at the other end the wheel M, by the perpendicular wheel N, of 30 teeth; the two ends of this rod are ſupported by the two ſtands that hold the other pieces. Under the piece K, that joins to the quadrant, muſt be placed the ſpring R, by which it is raiſed, and puſhes up the cylinder that goes through the ſtand C, into the egg.

You muſt alſo have ſix ſmall etwees or caſes as Y, Fig. 3. They muſt be of the ſame circumference with the cylinder in the ſtand, and round at their extremities: their length muſt be different, that when they are placed in the egg, and the lower end enters the hole in which is the cylinder, they may thruſt it down more or leſs, when the top of the egg, againſt which they preſs, is faſtened down; and thereby lower the bar that is fixed to the end of the quadrant, and conſequently, by means of the pinion F, and wheels N, M, turn the horſe-ſhoe that is placed upon the axis of the laſt wheel*.

In each of theſe etwees place a different queſtion, wrote on a ſlip of paper rolled up, and in each of the vaſes put the anſwer to one of the queſtions; as you well know, by trials, where the magnetic bar or horſe-ſhoe will ſtop.

Laſtly provide a ſmall figure of a ſwan, or what other you pleaſe, made of cork or enamel: in which you muſt fix a touched needle, of the largeſt ſize of thoſe commonly uſed in ſewing.

Being thus prepared, you offer a perſon the ſix etwees, and deſire him to chooſe any one of them himſelf, and conceal the others, or give them to different perſons. He is then to open the etwee, read the queſtion it contains to himſelf, and return the etwee to you, after replacing the queſtion. You then put the etwee

* The exact length of theſe etwees can be determined by trials only; which trials, however, may be made with round pieces of wood.

etwee in the egg, and placing the ſwan upon the water in the baſon, you tell the company ſhe will preſently diſcover in which of the vaſes the anſwer is contained. The ſame experiment may be repeated with all the etwees.

This apparatus is more commodious than that of the ſiren, as it may be eaſily moved from one place to another, and as there is here no occaſion for a confederate. But at the ſame time it will not admit of ſo great a variety of experiments.

CONSTRUCTION OF THE COMMUNICATIVE BELL.

LET there be made a box of copper in the form of part of a hollow covered cylinder, as AB (Pl. XVII. Fig. 1.) This box muſt be placed upon the circle of wood C, that has at its center a pivot, on which is to be placed a touched needle D, three inches long, and thicker than the common needles; at each end it muſt have a very ſmall braſs knob, and near to one end of it there muſt be placed a ſmall bell F, like that of a repeating watch; the bottom of this box muſt be cloſed with a gauze, that the needle may not be viſible.

On the inſide of the magnetic table, Pl. XIV, place a double bar MO, of about five inches long, ſtrongly impregnated, and fixed on an axis, under which is placed a double pully of an inch diameter. To one part of this pulley fix a ſmall cord, the other end being faſtened to the ſpring N. From the other part of the pulley muſt go a cord that paſſes over another pulley at A, and from thence, through the leg H, and behind the partition W; in the ſame manner as in the experiment of the ſiren.

The motion of this cord being conſtantly the ſame, and of very little extent, a lever may be fixed behind the partition, by which the magnetic bar may be readily moved from B to C.

This preparation being made, when you place the copper box or cylinder on the table, in ſuch manner that the pivot which holds the needle is directly over

that

that which holds the magnetic bar in the table *, if the lever behind the partition be thruſt down, the bar will be moved from B to C, and will cauſe the ſame motion in the needle, and conſequently make it ſtrike againſt the bell in the cylinder.

RECREATION XLVIII.

To tell by the communicative bell, the card that a perſon has drawn from the pack.

YOU are firſt to obſerve, that the ſounding of the bell ſignifies *yes*, and its ſilence *no*.

Open the pack before the perſon, and dextrouſly preſent that card to him which you have agreed on with your confederate. When the perſon has drawn that card you interrogate the bell, after the following manner. Suppoſe the card drawn to be the knave of ſpades.

Queſtions.	Anſwers.
Do you know the perſon that has drawn the card?	Yes.
Is it a gentleman?	No.
Is it a lady?	Yes
Do you know her?	Yes.
Is ſhe handſome?	Yes.
Are you ſure you know the card?	Yes.
Is it a diamond—a heart—a club?	No.
Are you ſure you are not miſtaken?	Yes.
Is it then a ſpade?	Yes.
Is it the king—ten—nine of ſpades?	No.
Is it the knave?	Yes.

This manner of anſwering queſtions may be applied to various intentions: as to naming the hour, or the number of perſons in company, &c. The foregoing Recreation is ſufficiently common; the following is ſomething more extraordinary.

To

* There muſt be a mark on the cylinder, by which you will be directed in placing it on the table.

To tell, by the bell, at what number, from the top, any card of a pack is, that a perſon ſhall name.

To perform this Recreation you muſt be provided with a piquet pack of cards, in which the ſeveral ſuites are placed in the following order, diamonds, ſpades, hearts, and clubs: and the cards of every ſuite in their natural rank, as ace, king, queen, knave, ten, &c.

You ſhuffle them, according to the manner preſcribed in p. 42. of the firſt volume, and they will then be in the following order.

1 Knave	clubs	17 Eight	diamonds
2 Ten		18 King	ſpades
3 Eight	hearts	19 Queen	
4 Seven		20 Knave	
5 King		21 Eight	
6 Queen		22 Seven	
7 Ten	ſpades	23 Ace	hearts
8 Nine		24 Knave	
9 Seven	diamonds	25 Ten	
10 Ace	ſpades	26 Nine	
11 Queen	diamonds	27 Ace	clubs
12 Knave		28 King	
13 Ace		29 Queen	
14 King		30 Nine	
15 Ten		31 Eight	
16 Nine		32 Seven	

A copy of this arrangement your confederate muſt have. Therefore when the perſon has named the card he chooſes, he who is behind the partition hearing what card it is, either by the other's naming it, or your repeating it, by looking on his ſcheme will ſee the number at which it is placed, and immediately ſtrike that number on the bell.

This Recreation is the more extraordinary, as it may be repeated a ſecond or third time, by your ſhuffling the cards in a determinate order; nothing more being neceſſary than for the confederate to have a ſcheme of the ſituation of the cards after each ſhuffle.

RECRE-

RECREATION XLIX.

The magnetic balance.

YOU muſt have a ſmall balance, ſuch as is commonly uſed for weighing money, as AB (Plate XVII. Fig. 2.) It ſhould be very exact, and the ſcales muſt be iron or ſteel, very thin, and gilt or lacquered. This balance muſt be ſupported by a ſtand fixed to the top of the magnetic table. The bottom of the ſcales ſhould not be above half an inch diſtant from the table.

You muſt obſerve, that they are to be placed over that part of the table where is the magnetic bar that is uſed for the ſiren and bell: ſo that the centers of the two ſcales are to be over the points O and M. Theſe ſcales muſt be ſtrongly touched, that they may be the more eaſily attracted by the magnetic bar.

This preparation being made, you aſk a perſon to lend you two pieces of money, ſuppoſe two guineas, and you place them in the ſcales, which will remain in equilibrium, if the pieces be of equal weight. You then propoſe to the perſon to augment the weight of either of them at pleaſure, and when he has determined, your confederate behind the partition, by means of the lever, moves the bar toward one of the ſcales, and it immediately deſcends. You then, if required, make the ſame experiment with the other ſcale.

To give your confederate notice which ſcale is to be moved, nothing more is neceſſary than to ſay, is it *this*, or is it *that* ſcale; you having previouſly agreed with him which ſcale the words *this* or *that* ſhall ſignify.

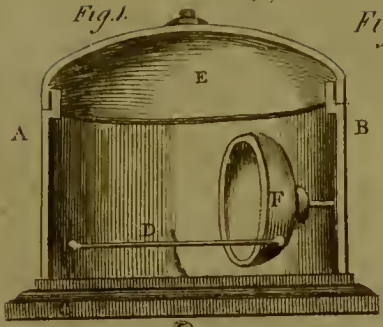
RECREATION L.

The ſympathetic dials.

LET there be two dials conſtructed of the ſame form and ſize. The movements of each conſiſting of a barrel A, and the four wheels A, B, C, D, with their pinions, and the fly F. The ſame as in the ſtriking part of a clock or dial. (See Pl. XVII. Fig. 3.)

The

Fig. 1.



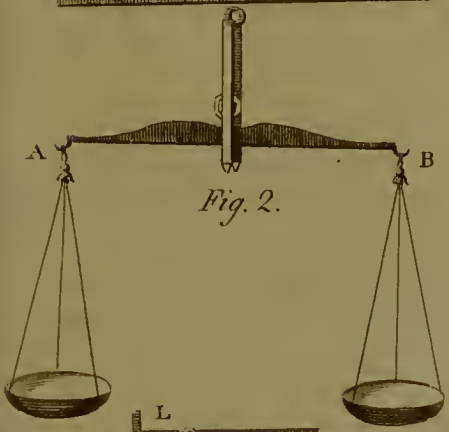


Fig. 2.

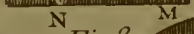


Fig. 4.

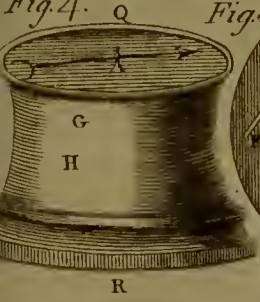


Fig. 3.

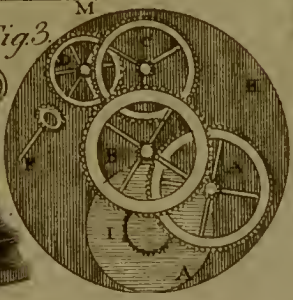


Fig. 5.



The movements of each of them must be enclosed between two plates of brass G and H, Fig. 4, of about two inches and a half diameter, and distant from each other about two-thirds of an inch. Let the axis of the wheel C pass through the center of the upper plate G, which is to be covered with a dial plate, that serves for ornament only. On the same axis place a needle or index, as in a common dial.

Under the plate H, Fig. 3. and on the axis of the barrel, continued out beyond the plate, fix a wheel with a catch, by which the movement of each of the dials may be wound up.

To one of these dials let there be a catch or trigger on the outside, by which it may be stopped or put in motion with a touch of the finger. To the other dial fix the catch L N M, whose axis is at N; the end L takes the fly of the movement, and consequently when the other end is thrust back the wheels are at liberty to move. This catch is to be placed on the brass wheel H, near the part I. It is to be of steel, well polished and touched, with its south pole at M. Great care must be taken to make this part move extremely free, that it may be easily attracted by the bar in the magnetic table, on which it is to be placed. Each of these dials is to be enclosed in a case of thin copper or brass Q R.

On the inside of the magnetic table, Pl. XIV. place the piece O P, composed of four steel oars strongly impregnated: they should be seven or eight inches long, half an inch wide, and one inch thick: they must be bound close together by four brass rings, of which that next P should be larger than the rest, and standing out beyond the bars, should have a hole through it, by which it is to be fixed on a pivot at P. These bars are to be drawn toward N, where they are to be stopped by the spring R. There must also be a string, which passing over the pullies S and T, goes down the leg of the table; the bottom of which is to be a lever or treddle, under the step, by means of which the piece O P may be moved by your foot.

You

You therefore place the second dial on the table, directly over that part where the extremity of the bars OP is; when you put your foot upon the lever at the bottom of the table. Therefore if you then place your foot on that lever, the bars attracting the end M, of the catch, will set the fly at liberty, and the wheels being put in motion, the index on the front of the dial will move with considerable velocity; but when you take your foot off the lever, the catch will again take the fly, and stop the movement.

Therefore having placed the second dial as above directed, you give the other dial, that had the end of the catch on the outside, to any person, and tell him, that when he shall stop it, or put it in motion, the dial on the table will, by sympathy, do the same, and by mounting the step you make it perform accordingly. You may also tell him that the dial on the table shall either stop or go, at his command: but this perhaps may destroy the notion of the dials acting by sympathy.

You may contrive to have stops or levers at different parts of the room, by carrying the cord under the floor: or in an adjacent room, to be moved by a confederate.

CONSTRUCTION OF THE MAGNETIC ROLLER.

PROVIDE a board two feet and a half long, three inches and a half wide, and half an inch thick, (see Pl. XVII. Fig. 5.) and divide it into ten equal parts, in each of which describe a circle, and divide its circumference likewise into ten equal parts. In each of the circles make a groove, and in each groove place a magnetic bar, whose poles are to be disposed as in the figure. Under each end of the board place a roller, on which it is to move the magnetic table, Pl. XIV.

To the end A of the roller (see Pl. XIV.) fasten a cord, which is to pass over a pulley at B, and go down the leg of the table: to the end of this cord is to be fastened a weight, inclosed in a bag, which is to pass freely up and down the hole at B. To the other end B of the roller, there must likewise be fastened a cord, which

which paſſing over a pulley at A, going down the leg of the table, and through the ſtep at the bottom, comes out behind the partition W.

Againſt the other ſide of the partition place the table in page 98; and at the top of it fix a pulley, over which muſt paſs a ſtring, with a weight at the end, and to the ſtring muſt be faſtened an index; as in the experiment of the ſiren.

The table is formed in the following manner. You are firſt to determine by trials, the ſpace that the index faſtened to the ſtring paſſes over, while each of the ten diviſions of the roller comes to the point S, in the magnetic table, and mark them down on the plan. Then divide it into five columns. In the ten diviſions of the firſt column write the numbers 10, 9, 8, 7, 6, 5, 4, 3, 2, 1. In the ten diviſions of the ſecond column write the vowels A, E, I, O, U, and the five conſonants D, G, L, N, R. In the diviſions of the third column write the figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. In the fourth column, in every other diviſion, in every other diviſion, write the name of one of the five following cards, eight of ſpades, ſeven of ſpades, eight of diamonds, ſeven of diamonds, ace of ſpades. In the fifth column write after the ſame manner, the names of five ſtates, as England, Portugal, Spain, Pruſſia, Auſtria. You may place what other letters you pleaſe in the ſecond column, but they ſhould be ſuch as by their combinations will produce ſeveral words. The words in the fourth and fifth columns may likewiſe be changed for ſuch as will anſwer to any other queſtions you chooſe.

TABLE.

Diviſions	Letters	Figures	Cards	States.
10	A	1		England
9	E	2	8 ſpades	
8	I	3		Portugal
7	O	4	7 ſpades	
6	U	5		Spain
5	D	6	8 diamonds	
4	G	7		Pruſſia
3	L	8	7 diamonds	
2	N	9		Auſtria
1	R	0	ace ſpades	

Now it follows from what has been ſaid, that when the perſon behind the partition fixes the index in the cord againſt any one of theſe diviſions, the part of the roller which correſponds to that diviſion will be brought oppoſite to the point S, in the magnetic table, and conſequently the touched needles in the pieces hereafter deſcribed, will place themſelves in the ſame direction with the bar in that part of the roller.

RECREATION LI.

The magician's box.

FIRST conſtruct the baſe AB, (Plate XVIII. Fig. 1.) of ſix inches long, four wide and one deep. Let it

Fig. 2.

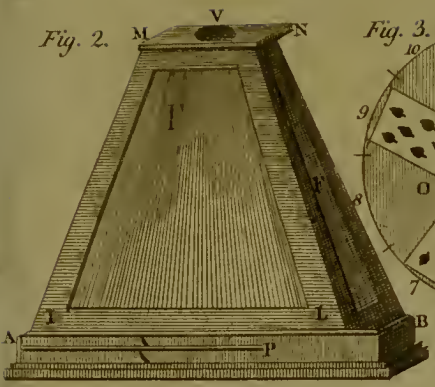


Fig. 3.

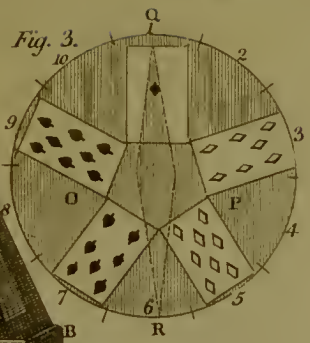


Fig. 1.

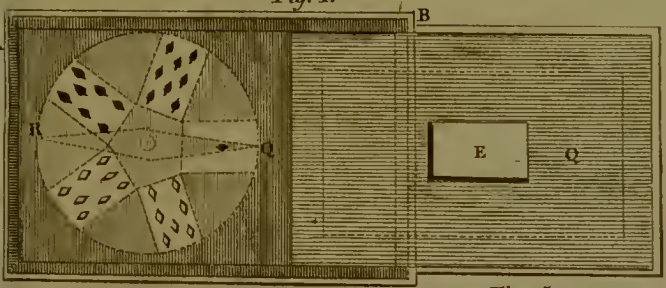


Fig. 4.

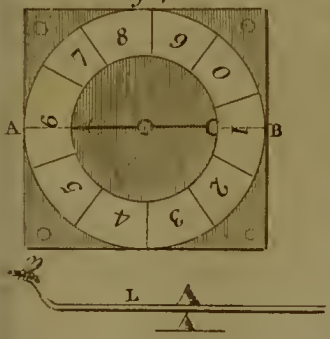
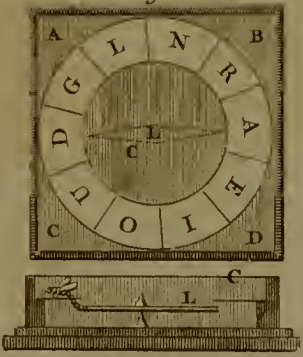


Fig. 5.



it be hollow, and covered with a piece Q, that ſlides in a groove. In the middle of the top piece make a hole, either ſquare or round, of about half an inch wide.

On this baſis place four panes of glaſs F, Fig. 2, joined together in the form of a truncated pyramid, and lined with gauze, or thin paper. At its bottom IL, it ſhould be two inches and a half ſquare; but at top MN, only one inch and a half. At the opening place a convex glaſs V, of five inches focus, that is equal to the height of the machine. Let it be fixed to the baſe AB.

On the inſide of the baſe, and at two inches diſtance from one of its ſhorteſt ſides, fix a pivot, on which is to be placed the circle of paſteboard OP, Fig. 3, of four inches diameter, in which muſt be fixed the touched needle QR. The paſteboard circle muſt be divided into ten equal parts, as in the figure; which parts are to correſpond to the diviſions in the foregoing table. In the five diviſions 1, 3, 5, 7, 9, are to be drawn the cards there expreſſed.

On a ſecond circle of paſteboard, that has the ſame diviſions, write in thoſe marked 2, 4, 6, 8, 10, the five names of different ſtates, mentioned in the foregoing table.

As each circle muſt be previouſly placed on the baſe, and changed for every different recreation, it will be proper to have two boxes, as it would be impolitic to change the circles before the ſpectators. It would be ſtill much better if the box could be placed in a cheſt or cabinet, that was fixed againſt a partition, behind which a confederate is placed; for then, after performing one recreation, the box might be placed in the cabinet, and the confederate, by a private opening in the partition, might take out the circle, and inſert another.

It will be eaſy to conceive, from what has been ſaid, that when the machine is placed on the magnetic table, at the part S, ſo that the pivot on which the circle turns is exactly over the point S, the bar in the part of the roller then there will put the needle in a ſimilar

direction, and consequently by looking into the machine, the spectator will see the card, letter or word, that is opposite the index in the table of columns.

A person is to name the state in which the city whose name is on the cards that have been dealt to another.

On thirty cards write the names of the five following cities; London, Lisbon, Madrid, Berlin, Vienna. Then shuffle and deal them after the manner explained in p. 42, of the first volume.

Then tell the second person to look into the box, and read the name of the state in which is the city whose name is on the cards in the first person's hand. The same is to be done for the four other parties.

To perform this recreation, nothing more is necessary than to have a circle with the name of the five states: and that the confederate be instructed in the order that each name is to be brought forward to the eye of the spectator.

In recreations of this kind it will be proper to have a hole in the partition, by which the confederate will know when to move the circle, and keep it steady till he who performs the experiment has covered the eye-glass of the box.

RECREATION LII.

The mystical dial.

PROVIDE a board four inches square, and let it be supported at the four corners by feet about one quarter of an inch high, as AB (Plate XVIII. Fig. 4.) On this board draw two concentric circles, and divide them into ten equal parts, in nine of which write one of the numbers from 1 to 9, and in the tenth an 0. These numbers must be placed in the same manner as in the figure, and the line AB must divide the divisions marked 1 and 6, into two equal parts. At the center of this dial place a needle of a convenient size.

It is evident from the construction of this dial, that when the person behind the partition places the index

of

of his table againſt any number in the third column, the needle of this dial, when it is placed over the roller in the magnetic table, will point to the ſame number.

To ſhew by the foregoing dial, the numbers that two perſons have choſe, their ſum or their product.

You muſt here have the ſmall bag deſcribed in p. 62: in the firſt diviſion of which put the numbers from 1 to 10, and in three other diviſions any numbers you pleaſe, ſuppoſe 3, 7, and 8; that is, all the tickets in each of thoſe three diviſions muſt have the ſame number. You then offer two different diviſions of the bag to two perſons, and they each draw one number, ſuppoſe 5 and 7, you having previouſly agreed with your confederate what the numbers are to be. You then aſk them whether the index ſhall point to their numbers ſucceſſively, their amount, or their product when multiplied together.

If the numbers are to appear ſingly, the confederate firſt directs the index of his table to the number 5, which you are to allow him a ſufficient time to do. You then place the index on the dial, and turning it about it will ſtop at that number. You take off the index while your confederate moves the ſlider, and placing it on again it will then ſtop at 7.

If the amount of the two numbers be required, the confederate directs his index firſt to one and then to 2, which make 12. If the product be required, he directs the needle, in like manner, firſt to 3 and then to 5, which make 35.

You muſt obſerve to take the needle off the pivot immediately after it ſtops, before the roller begins to move again: and as the needle will place itſelf directly in the poſition of the bar underneath, you muſt turn it about as ſoon as you have placed it on the pivot. Attention ſhould be had to this obſervation in all the experiments with the magnetic needle.

RECREATION LIII.

The magical game of all fours.

TO perform this Recreation you muſt have a paſte-board circle, on which there are twelve diviſions, on ſix of which cards are to be painted, and to which ſix diviſions of the roller muſt be adapted. A pack of cards are to be previouſly ranged and ſhuffled, after the manner deſcribed in the firſt volume, p. 42, and when they are dealt, the hands are to be as follows.

Eldeſt		Youngeſt	
King	ſpades	Ace	ſpades
Ten		Queen	
Ace clubs		Nine	
Ace diamonds		Ace	hearts
King	hearts	Queen	
Knave		Eight	

Turn-up card, knave of ſpades.

The eldeſt takes up his cards. Thoſe dealt for the youngeſt lie on the table. Now the natural way of playing the above cards would be as follows: firſt, the eldeſt hand would lead one of his aces, which the youngeſt would win with his nine of trumps; and then play his ace and queen of hearts, the latter of which the eldeſt would win with his king: he would next lead his other ace, to which the youngeſt would play his eight of hearts. The eldeſt muſt then lead from his king and ten of trumps, both which the youngeſt muſt take with his ace and queen, and conſequently have higheſt, loweſt, and game, which with the knave turned up, will make him all-fours.

Therefore when the eldeſt plays, you ſay aloud to another perſon, the gentleman plays the ace of clubs, for example, look in the box and ſee what card I muſt play; when your confederate will directly bring the nine of trumps on the circle to view. When it is your turn to play, you have no occaſion to ſay any thing, but only deſire the perſon to look in the box and ſee what

what card is played, your confederate having directions what to do. Thus you go on till the eldeſt has played all his cards. But you muſt obſerve, each time the circle is to be moved to prevent the perſon from immediately looking into the box, by ſome amuſing diſcourſe; or it might be better to ſtand by the the box yourſelf, in order to cover and uncover it each time the perſon is to look in, that the circle may have time to ſettle.

RECREATION LIV.

The intelligent fly.

AT the center of a box about ſix inches ſquare and one inch deep (Plate XVIII. Fig. 5.) place a pivot. Have a touched needle L, three inches and a half long, and at the end of it that is touched fix a fly made of enamel: the other end of the needle muſt be ſomething heavier, to keep it in equilibrio. This needle is to be placed on the pivot.

On a piece of ſquare paſteboard that will juſt go into the box, draw a circle, ABCD, three inches and a half diameter; and another at a ſmall diſtance, concentric with the former. The part within the laſt circle muſt be cut out. This paſteboard circle is to be placed about half an inch from the bottom of the box, and divided into ten equal parts, in which are to be wrote the letters A, E, I, O, U, D, G, L, N, R, as in the figure.

Place a glaſs about half an inch above the circle, and cover it with a circle of paper C, large enough to hide the needle, and leave only the fly viſible: on this paper you may paint ſome allegoric figures, that its uſe may not be ſuſpected. You muſt next write on 24 cards the following queſtions. Theſe cards are to be packed and ſhuffled, according to the method explained in the firſt volume, p. 42, that they may be in the order the queſtions are here placed.

QUESTIONS.

QUESTIONS.

1. Which is the land of liberty? 2. Which is the firſt city in the world? 3. Whom do many men deſpiſe, though they have not half his merit? 4. Who is the pooreſt man in the world? 5. Who is the meaneſt of all mankind? 6. For what do all young women long? 7. Who, by ſtation, is the moſt miſerable of all beings? 8. By what does a man diſcover his weakneſs? 9. What would every married woman do if ſhe could? 10. In what does a man ſhow his pride and folly? 11. What makes a woman cry more than the loſs of her huſband? 12. How does a man talk who has nothing to ſay? 13. What moſt reſembles a fine lady? 14. What frequently reminds us of a great loſs, without giving diſguſt? 15. What makes a young woman in love with an old man? 16. What does the poet want to cover his empty ſkull? 17. What ſhould a man never take from the woman he loves? 18. What muſt that man be who would gain the eſteem of all? 19. Who is he that ſeeks a man's company when his money and friends are all gone? 20. What gains the good will of the phyſician, the lawyer, and the harlot? 21. What do good men revere and knaves abuſe? 22. What does a man depend on when he truſts to his friends for ſupport? 23. What can he be ſure of, who leaves his affairs to another? 24. What makes as great a difference almoſt, if not altogether, between this man and that, as between that and a brute?

After you have ranged the cards in the manner before mentioned, you place them on the table, and aſk any perſon which of them, in the order they then ſtand, ſhall contain the queſtion to which the fly ſhall give him the anſwer. If he ſay, for example, the 20th; your confederate, who has the following copy of the anſwers, will make the needle, at the end of which the fly is, ſucceſſively point to the letters that compoſe that word: then counting the cards over till you come to the 20th, you will find that word anſwer the queſtion.

ANSWERS.

Fig. 1.



Fig. 2.

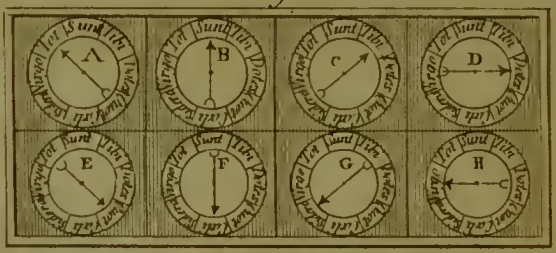
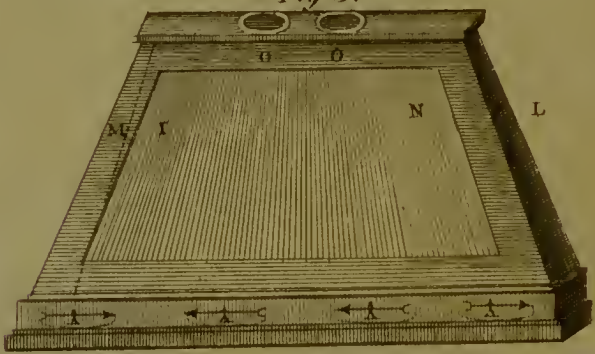


Fig 3.



ANSWERS.

1. England. 2. London. 3. A dog. 4. A niggard. 5. A liar. 6. A ring. 7. A nun. 8. Anger. 9. Rule. 10. A duel. 11. An onion. 12. Loud. 13. An angel. 14. A dial. 15. Gold. 16. A laurel. 17. A denial. 18. Generous. 19. A dunn. 20. A guinea. 21. Religion. 22. A reed. 23. Ruin. 24. Learning.

Many other Recreations may be performed by this intelligent fly by numbers, cards, &c. similar to thoſe we have already explained on other occaſions, and which, to avoid the appearance of a repetition, we ſhall not here deſcribe.

RECREATION LV.

The multifarious verſe.

THE eight words that compoſe this Latin verſe,

*Tot ſunt tibi dotes quot cœli ſidera virgo**.

being privately placed in any one of the different combinations, of which they are ſuſceptible, and which are 40,320 in number, to tell the order in which they are placed.

Provide a box that ſhuts with hinges, and is eight inches long, three wide, and half an inch deep (Plate XIX. Fig. 1.) Have eight pieces of wood about one-third of an inch thick, two inches long, and one and a half wide, which will therefore, when placed cloſe together, exactly fill the box. In each of theſe pieces or tablets place a magnetic bar, with their poles as is expreſſed in the figure. The bars being covered over, write on each of the tablets, in the order they then ſtand, one of the words of the foregoing Latin verſe

On a very thin board of the ſame dimenſion with the box, Fig. 2, draw the eight circles, A, B, C, D, E, F, G, H, whoſe centers ſhould be exactly over thoſe of the eight tablets in the box, when the board is placed upon it. Divide each of thoſe circles into eight parts,

* Thy virtues, virgin, are as numerous as the ſtars of heaven.

parts, as in the figure, and in each of thofe diviſions write one of the words of the Latin verſe, and in the preciſe order expreſſed in the plate, ſo that when the board is placed over the box, the eight touched needles placed at the center of the circles may be regulated by the poles of the bars in the box, and conſequently the word that the needle points to in the circle be the ſame with that inſcribed on the tablet. Cover the board with a glaſs to prevent the needles from riſing off their pivots, as is done in the ſea-compaſs.

Over the board place four plates of glaſs, I, L, M, N, Fig. 3, which will give the machine the figure of a truncated pyramid, of eight inches high. Cover it with a glaſs, or rather a board in which are placed two lenſes O, of eight inches focus, and diſtant from each other about half an inch. Line the four plates of glaſs that compoſe the ſides with very thin paper, that will admit the light, and at the ſame time prevent the company from ſeeing the circles on the board.

Theſe preparations being made, you give the box to any one, and tell him to place the tablets on which the words are wrote, privately, in what poſition he thinks proper, then to cloſe the box, and if he pleaſe, to wrap it up in paper, ſeal it, and give it you. Then placing the board with the pyramid upon it, you immediately tell him the order in which the tablets are placed, by reading the words to which the needles on the circles point.

This recreation, which appears to have been invented by M. Guyot, is of the ſame nature with that of the box of numbers, that has been frequently exhibited, but much more entertaining. For here there is not only a vaſt number of combinations to be formed, but the words at the ſame time conſtantly preſerve one meaning. If the firſt inventors of this ſort of recreation had made uſe of words in this manner, inſtead of numbers, the inveſtigation would have been attended with much more difficulty.

RECRE-

RECREATION LVI.

The communicative mirror.

LET there be made a box AB, (Plate XX. Fig. 1.) the top of which draws off at the end A. Let it be on the inside nine inches long, six wide, and two-thirds of an inch deep. At the bottom of this box, and at three inches distance from the end A, fix a pivot, on which is to be placed the circle of pasteboard M, Fig. 2. that contains a touched needle. Divide this circle into four equal parts, in three of which paint three cards, in the position expressed in the figure.

In the top of the box make a hole an inch and half in diameter, over which place the pedestal CD, composed of four plates of glass, covered on the inside with very thin paper.

On the top of the pedestal place the tube EF, about six inches long, and one and a half in diameter. In this tube at M, is to be fixed an inclined mirror, by which the part of the pasteboard circle under the hole at L, may be seen by the eye at G. At the end F of the tube place an eye glass whose focus is equal to the distance GM: and at the end E, any glass you please. At the end B of the box, place the mirror TV, which serves to make the spectator think it is in that he sees the card on the pasteboard.

In the box ABCD, Fig. 3, that shuts with hinges, and is of the same dimension with the inside of the other box, are to be placed successively the three tablets X, Y, Z, in one determinate position. In each of these tablets must be fixed a magnetic bar, in the manner expressed in the figure, and on each of them is to be pasted one of the same cards with those on the pasteboard circle. One of these tablets as for example, that marked Z, being placed in the box, in the manner expressed in the third figure, the needle on the circle will place itself in a correfponding position, and the similar card on the circle will come under the pedestal. You therefore present the box, Fig. 3, and the three tablets,

to

to a perſon, deſiring him to place any one of them he thinks proper, in the box, privately; then to conceal the others, and after he has cloſed the box, to return it you. Then placing the firſt box with the pedeſtal, tube, and mirror over the other, you direct him to look in the ſeeming perſpective-glaſs, when he will ſee the figure of the card he placed in the box, and it will appear to him to be in the mirror TV.

You may have a fourth tablet, that contains a bar, but on which there is nothing painted. This tablet you may place firſt in the box, and let the party ſee that when there is no card in the box he cannot ſee any in the perſpective.

RECREATION LVII.

The box of dice by reflection.

LET there be a ſmall box of wood, ABCD, (Plate XX. Fig. 4.) ten inches long, two wide, and one and a half high. At the two ends of this box fix the two hollow cubes I, L, one inch and a half ſquare, in which are to be placed two dice exactly of the ſame dimenſion.

The ends AC and BD of the box are to have ſliders that draw up, in the manner expreſſed by Fig. 5. There muſt be likewiſe at each end a ſmall pannel M, that may be raiſed or depreſſed one-tenth of an inch, by which a ſmall hole at N may be covered or uncovered; and through this hole you are to ſee into the box.

The top and two longeſt ſides of the box are to be of glaſs, lined with a thin paper. Within the box are to be placed two mirrors OP and QR, at an angle of forty-five degrees, by which, when you look through the holes at the two ends of the box, you will eaſily ſee the bottoms of the two cubes I, L, that are placed on it.

Divide the bottoms of the cubes juſt mentioned into four equal parts, by diagonals drawn from the oppoſite angles, as in Fig. 8. and again divide that ſide next

Fig. 1.

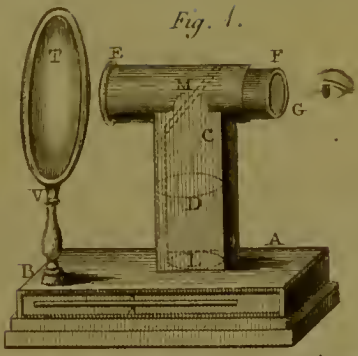


Fig. 2.



Fig. 3.









Fig. 4.



Fig. 5.



Fig. 7.



Fig. 8.

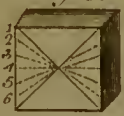
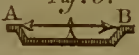


Fig. 6.



next the middle of the box into ſix equal parts, which are to correſpond to the ſix points that are on a die.

Under each of the cubes place a ſmall braſs ſtand AB, Fig. 6, which is to be diſpoſed as in Fig. 7. On the ſtand there muſt be a pivot, directly under the center of the cube, and it muſt hold two needles, one of braſs and the other of ſteel, and touched. Theſe needles are to be placed at right angles to each other, as in the figure.

Divide each face of a die into four equal parts, by diagonals from the oppoſite angles, and then divide each ſide into ſix equal parts, and in each ſide of the die, oppoſite to one of thoſe parts, each different from the other, place a magnetic bar one inch and a quarter long, two-tenths of an inch wide, and one tenth thick. All the diviſions on theſe dice muſt be very exact: cover them with double papers, and write on each ſide of them the points it is to expreſs, when its oppoſite ſide is next to the touched needle: they are then to be placed in the two hollow cubes, which are to be covered.

This machine being conſtructed with care, according to the foregoing directions, you preſent the two dice to any perſon, and deſire him to place them privately in the two cubes, in what poſition he pleaſe, and put on their covers. Then looking through the two holes, you immediately tell him, by the direction of the needles to the under ſides of the cubes, the exact number of points they compoſe.

PNEUMATICS.

DEFINITIONS.

1. THE atmoſphere is that body of air which every where furrounds the earth.

2. The air-pump is a machine contrived to produce a vacuum, by exhauſting the air out of the veſſel called a receiver.

3. The condenſer is an inſtrument generally in form of a ſyringe, to force a greater quantity of air into any veſſel than it naturally contains.

4. The animometer is an inſtrument that meaſures the ſtrength of the wind.

5. The hygrometer is contrived to ſhow the different degrees of moiſture in the atmoſphere at different times.

6. The thermometer meaſures the degrees of heat and cold of the air, and of other bodies.

7. The barometer ſhows the different weight of the air at different times.

APHORISMS.

1. The air is an elaſtic, ponderating, compreſſible and expanſible fluid, that is ſenſible only to the touch.

2. The elaſticity of the air is increaſed by heat and decreaſed by cold*.

3. The weight of the air is ſo ſmall as not to be perceived but in large quantities†.

4. The

* This is proved by the common experiment of tying the neck of an inflated bladder, and laying it before the fire: for the heat, by expanding the ſmall quantity of air in the bladder, will extend it to the utmoſt ſtretch, and at laſt burſt it, with a loud report. But if after the bladder becomes diſtended it be carried into the cold, it will immediately reſume its flaccid form.

† A gallon of air weighs one dram, nearly. A column of the atmoſphere, whoſe baſe is a ſquare inch is equal to 15 lb. conſequently the ſurface of a man's body, of ſix feet ſtature, being on average

4. The rarefaction and condenſation of the air, are indefinite*.

5. Though air is greatly condenſible by cold, it cannot be congealed.

6. Air is neceſſary to animal exiſtence.†

7. Aduſt air, that is ſuch as has paſſed through the fire or a heated tube, will not ſupport animal life.‡

8. Air is contained in almoſt all bodies, and may be produced from them.§

9. Sound is communicated by the air.‖

10. The atmoſphere is of different denſities at different heights, and is moſt denſe near the earth.¶

average equal to 14 ſquare feet, it muſt be preſſed by a weight of air equal to 28,000 pounds. This great weight is counteracted by the air within the human body; which, though ſmall in quantity, is, by its ſpring, ſufficient to balance the external air.

* Mr Boyle found that the air near the ſurface of the earth is compreſſed, by its own weight, into a ſpace leſs than 1-13000th part of the ſpace it would take up if left at liberty: and as the common air may be compreſſed into 1-60th part of its natural ſpace, it follows that the air may occupy a ſpace 780,000 times greater at one time than another. Dr Gregory has ſhewn, that if a globule of air of one inch diameter, had as great an expanſion as it would have at the diſtance of a ſemidiameter of the earth from its ſurface, it would fill all the planetary regions, as far as, and even beyond the ſphere of Saturn.

† This has been proved by many, far too many experiments, with the air-pump. It is not however univerſally true, for toads, vipers, eels, inſects of every kind, and fiſh, live in the exhauſted receiver.

‡ An animal put into a receiver filled with burnt air will expire immediately. Live coals and candles will likewiſe go out when put in ſuch air.

§ Air is produced from bodies by their diſſolution, that is by fermentation, diſtillation and ſimilar methods. The quantity of air produced from bodies is very different. Yellow wax contains one-ſixteenth, coarſe ſugar one-tenth, oyſter-ſhells and muſtard ſeed one ſixth, heart of oak one-fourth, peaſe, dry tobacco, and Newcaſtle coal one-third, and the calculus humanus, or ſtone found in the human bladder, one half of their ſeveral weights

‖ This is proved by the bell in the receiver of the air-pump, as will be ſeen in the Recreations.

¶ At the height of 42 miles the air is computed to be 4096 times more rare than at the ſurface of the earth.

11. The height of the atmosphere does not exceed 50 miles.*

12. Wind is nothing but a current of air.

13. The velocity of the wind is from 1 to 60 miles in an hour.†

THE PNEUMATIC APPARATUS.

OF all the pneumatic apparatus the air-pump is doubtless the most important, and that as well from its entertainment as the elucidation it affords to this branch of science.

The construction of the common air-pump is as follows. AA, Plate XXI. represent two brass barrels, in which the pistons C C act. The brass pipe H H is called the swan's neck, through which the air passes from under the receiver O O, by a small hole K in the middle of the brass plate I, on the top of the pump, to a brass piece in the box D D: which being perforated likewise to the middle point under each barrel, transmits the air by a bladder valve, to be pumped out.

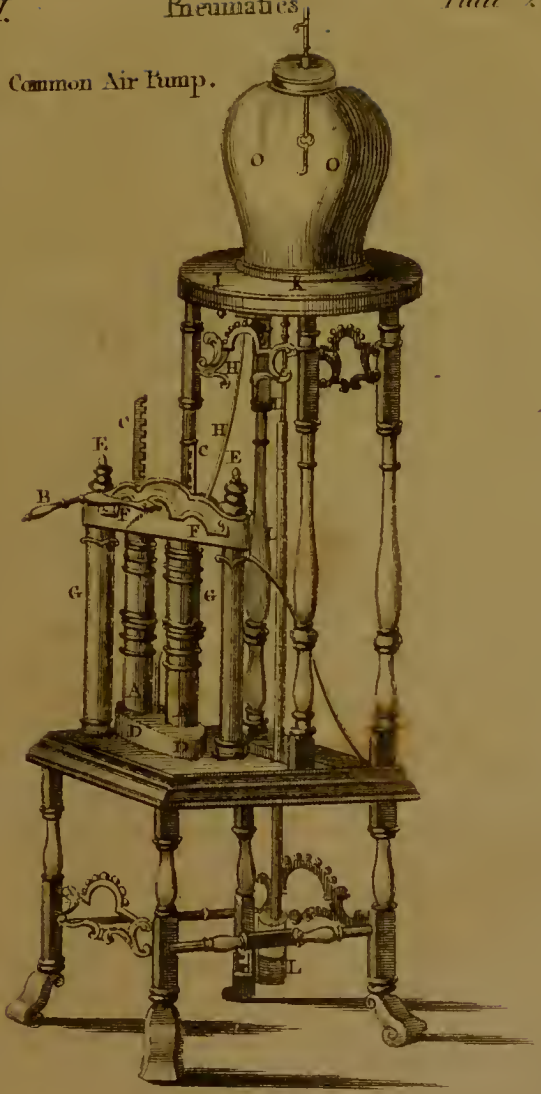
The mercurial gage which communicates with the receiver, is marked L L L. The stop cock N, serves to re admit the air, when necessary. B is the handle or winch for working the pump. G G are two pillars, supporting the frame of the pump wheel, which is screwed upon them by the two nuts, E E. The use of the other parts will readily appear from an inspection of the figure.

The

* As the air becomes continually more rare as its distance from the earth increases, it is impossible to determine its exact height, but by different experiments, especially by observing the duration of the twilight, it may be reckoned from 45 to 50 miles.

† It must be a very strong wind that goes 60 miles in an hour. The velocity of the wind at a medium, may be reckoned 12 or 15 miles per hour. If a person go the same way with the wind, and with an equal or greater velocity, he will not know there is any wind; while another going against it, or with a less velocity, will receive it very sensibly. Dr Derham found by repeatedly observing the space passed over by a feather, with a half second watch, in the great storm in 1705, that it was 33 feet per half second, which is equal to 45 miles per hour: from whence he concluded, that the most vehement wind, as that in November 1703, does not exceed 50 or 60 miles per hour.

Common Air Pump.



The operation of this machine depends on the elasticity of the air; for as the piston rises, the air in the receiver by its spring is forced into the barrel of the pump, through the valve at the bottom, which valve prevents its return into the receiver; the piston in its descent, then compresses the air in the barrel, by which means it is forced out through the valve in the piston, into the external air. By continually working the pump, the pistons act alternately and the receiver is gradually exhausted; but the air can never be totally drawn out, so as to leave a perfect vacuum; for it must be remembered, that the air is forced into the barrels by the spring of that which remains in the receiver; therefore to exhaust every particle, the last must be expelled without an agent, which is absurd.

Such is the construction of the common air-pump; but there is another, invented by Mr Smeaton, by which a purer vacuum is obtained, and which also acts as a condensing engine. There is moreover, what they call a portable air-pump, which is placed on a table, and may be easily conveyed from one place to another.

THE ANIMOMETER.

THE construction of this instrument may be as follows. Let A B C D E F G H; (Plate XXII. Fig. 1.) be an open frame of wood, firmly supported by the post P. In the cross pieces I and L is moved an horizontal axis Q M, by means of the four sails, *a b*, *c d*; *e f*, *g h*, exposed to the wind in a proper direction. Upon this axis is fixed a cone of wood, M N O, upon which as the sails move round, a weight S is raised, by a string on its surface, proceeding from the small to the largest end N O. Upon the great end or base of the cone, is fixed a ratchet-wheel I K, in whose teeth falls the click X, to prevent a retrogade motion from the depending wheel.

It is easy to perceive, from the construction of this machine, that it is adapted to estimate the variable

force of the wind, becauſe the force of the weight will continually increaſe as the ſtring advances on the conical ſurface, by acting at a greater diſtance from the axis; and therefore if ſuch a weight be put on the ſmalleſt part at M, as will juſt keep the machine in equilibrio with the weakeſt wind; as the wind becomes ſtronger the weight will be raiſed in proportion, from S towards R; and the diameter of the baſe of the cone N O, may be ſo large, in compariſon of that of the ſmaller end or axis at M, that the ſtrongeſt wind ſhall but juſt raiſe the weight to the great end.

Let the diameter of the axis, for example, be to that of the baſe of the cone N O, as 1 to 28. Then if S be a weight of one pound on the axis at M, it will be equivalent to 28 pounds, or one-fourth of a hundred weight, when raiſed to the greateſt end. Therefore, if when the wind is weakeſt it ſupport one pound on the axis, it muſt be 28 times as ſtrong to raiſe the weight to the baſe of the cone. It follows that if a line of 28 equal parts be drawn on the ſide of the cone, the ſtrength of wind will be expreſſed by the number on which the ſtring ſhall at any time hang.

This ſtring may, moreover, be of ſuch a ſize, and the cone of ſuch a length, that there may be 16 revolutions of the ſtring between each diviſion of the ſcale on the cone; by which mean the ſtrength of the wind will be expreſſed in pounds and ounces. If ſtill greater accuracy be required, let the periphery of the cone's baſe be divided into 16 equal parts: then, wherever the equilibrium happens, the ſtring will leave the conic ſurface againſt one of thoſe diviſions, and conſequently ſhow the force of the wind to a dram averdupoiſe weight.

THE CIRCULAR HYGROMETER.

TAKE a board ABCD, about a foot ſquare (Pl. XXII. Fig. 2.) and bind it round either with four pieces of iron, or dry hard wood, about half an inch thick, to prevent it from enlarging, to any ſenſible degree, by the moiſture of the air. At the ſeveral parts marked C,

Fig. 1.

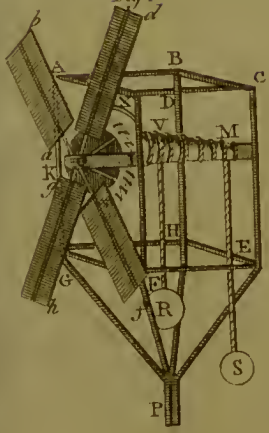


Fig. 2.

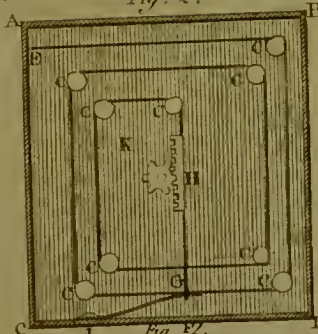


Fig. 4.

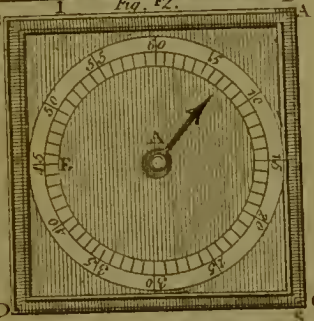
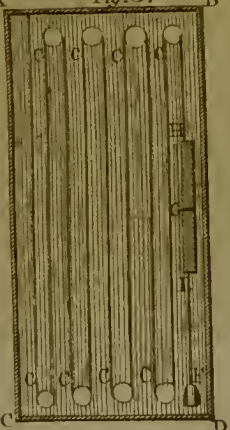
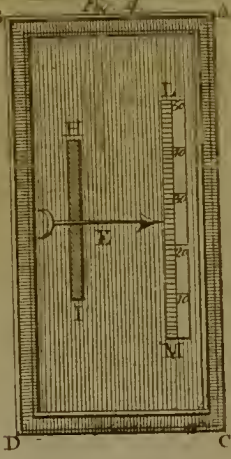


Fig. 5.



Fig. 3.





C, in the figure, place pullies of about half an inch diameter, and that turn quite free on their axis. At E fix one end of a catgut, of the ſize of the ſmalleſt ſtring of a violin; let it paſs over all the pullies and be fixed, by the other end to the ſpring F, which is to be adjuſted by the ſcrew I, ſo as to have more or leſs force.

Near the center of the board is to be fixed to the catgut a braſs ruler H, about an inch long, and that has 20 or 25 teeth, which are to take thoſe of the pinion K, whoſe axis, which is in the center of the board, paſſes through it, and ſtands out on the other ſide, on which is to be fixed a very ſlight index, (ſee Fig.) and round the center deſcribe the circle E. Cover that ſide of the board on which are the pullies, with a cloth.

As the moiſture of the air will contract the catgut, which is near ſix feet long, and the dryneſs extends it; by means of the ſpring the braſs ruler will aſcend in the firſt ſtate, and deſcend in the other, and by its motion will neceſſarily turn the pinion and index.

To regulate this hygrometer, the circle E being divided into 60 equal parts, as in the figure, chooſe a time when the air is very dry, and fix the index againſt the firſt degree, and as the air becomes moiſt the index will ſhow, by the number of diviſions it paſſes over, the degree of that moiſture. If the index ſhould be found to make more than a complete revolution, the ſpring to which the catgut is faſtened, muſt be contracted.

THE PERPENDICULAR HYGROMETER.

ON the board ABCD, that is a foot long and three inches wide, (Plate XXII. Fig. 3) let a catgut paſs over the eight ſmall pullies marked C, and be fixed at one end to the top of the board, and at the other to the weight F. To the catgut faſten a ſmall piece of braſs at G, which moves freely in the groove H I, and to the end that is in the other ſide of the board, fix the index E, Fig. 4. which, as it aſcends and deſcends,

ſcends, mark the degrees of dryneſs or moiſture on the ſcale L M.

This hygrometer has not ſo great an extent as the former, but is more ſenſible, as having a greater length of ſtring, and no friction of teeth, and it is more eaſily conſtructed; nothing being here neceſſary but to adjuſt a proper weight to the end of the ſtring, and to make the pullies move quite free, for which purpoſe they ſhould be frequently oiled.

But the moſt ſimple, and at the ſame time the moſt ſenſible hygrometer, may be conſtructed as follows. Let R S, Fig. 5. be a catgut or whipcord that goes from one end of the room to the other, near the ceiling, and paſſing over the pulley T, deſcends in a corner of the room to V, where it is faſtened to a weight ſufficient to keep it always ſtretched. This weight is to hang free from the wall, and there is to be faſtened to an index X, which points to a ſcale of wood or paper Z, that is placed againſt the wall. As this hygrometer has no other friction than that of a ſingle pulley, and may have, in a ſmall room, 18 or 20 feet of ſtring, it is certainly more eligible than either of the foregoing, and perhaps, than any of the numerous and complicated hygrometers that have been invented.

THE THERMOMETER.

THE figure of this inſtrument, as well as that of the barometer, is too well known to need deſcription. It will be ſufficient here to ſhow their conſtruction and the principles on which they act.

As the thermometer is deſigned to ſhow the degrees of heat and cold by the expanſion of a fluid, different fluids have been uſed for that purpoſe. The firſt that became generally uſed was ſpirit of wine tinged with cochineal. This thermometer anſwers very well for common purpoſes, but in great degrees of heat, as that of boiling water or oil, or melting metals, the ſpirit will burſt the tube; and in a great degree of cold it will freeze. This, therefore, was ſoon rejected by philoſophers, and was ſucceeded by thoſe made with linſeed

ſeed oil; which requires four times the heat to make it boil, that water does. This ſort of thermometer was conſtantly uſed by Sir Iſaac Newton, and with this he meaſured the comparative heat of boiling water and ſpirit of wine, and of melting wax, tin and lead; beyond which it does not appear to have been tried.

There was ſtill wanting a thermometer that would meaſure any degree of heat, and this was invented by Farenheit of Amſterdam, whoſe name it ſtill bears. It is made of mercury, which expands itſelf uniformly from the hardeſt froſt to the greateſt heat. The common ſort of theſe thermometers have a ſcale that begins with 0, the freezing point is 32, and is extended to the heat of boiling water, which is 212 degrees. It was this thermometer the great Boerhaave conſtantly uſed in his chemical and other experiments. We forbear any further deſcription of the manner of conſtructing this inſtrument, as it cannot be performed to a due degree of accuracy, but by an able workman.

THE BAROMETER.

THIS inſtrument, when properly conſtructed, is the moſt generally uſeful of all the pneumatic apparatus. The barometer is frequently called the Torricellian tube, from its inventor, an Italian, and diſciple of the renowned Galileo, named Torricelli; who, conſidering that a column of water of about 33 feet, was equal in weight to a column of air of the ſame baſe, concluded that a column of mercury of about 29 inches and a half would likewiſe be equal to a column of air, for ſuch a column of mercury he knew to be equal to 33 feet of water; he accordingly made the experiment, and the apparatus he then uſed is now the common barometer.

The principal defect in the common barometer is the ſmallneſs of the bore of the tube, which occaſions the mercury to adhere to its ſide, and not riſe and fall with the neceſſary freedom. Therefore, procure a glaſs

glaſs tube one-third, or at leaſt one-fourth of an inch diameter, hermetically ſealed at one end and open at the other, and 34 inches long: its inner ſurface muſt be perfectly clean, and that it may be ſo juſt before you uſe it, rub the inſide with a piece of fine warm flannel put round a wire. Have ready a ſmall quantity of pure mercury, which you may ſqueeze through a thin leather. Then quite fill the tube with mercury, and having ready a glaſs baſon, or drinking glaſs with a flat bottom, about an inch and a half or two inches high, in which likewiſe ſome of the ſame mercury is put, invert the tube, and put it in the baſon, ſtill holding your finger under it, till it is in the mercury of the baſon; then place it in a frame. On taking away your finger, the mercury in the tube will immediately ſubſide to about 29 or 30 inches, according to the ſtate of the air, it being very rarely lower than 28, or higher than 31 inches. Therefore if a ſcale of four inches, divided into tenths, be placed againſt the upper end of a tube, the brometer is complete.

Though the ſcale be only divided to tenths of an inch, yet if there be an index from the ſcale to the tube, as is commonly practiſed, the eye may diſtinguiſh to the 20th or 40th part of an inch, that is to one-half or one quarter of a tenth. But for greater preciſion there is what they call from its inventor, a Nonius diviſion, which is a ſmall plate ſo contrived as to ſlide over the graduated plate or ſcale, in ſuch manner that its index may always be ſet, in one part to the ſurface of the mercury, while another part correſponds with one of the diviſions of the ſcale. Now, this Nonius is divided into ten equal parts, which are together equal to eleven diviſions of the ſcale, that is eleven-tenths of an inch. Conſequently every diviſion of the Nonius is equal to one and one-tenth of the ſcale; two of them to two and two-tenths; three of them to three and three tenths, &c. Whence it is eaſy to conceive, that if the Nonius index points between any two diviſions of the ſcale, you need only look back to ſee what diviſion

diviſion of the Nonius coincides with a diviſion of the ſcale, and that will ſhow the number of tenths of a tenth; that is, the hundred parts of an inch.

The barometer may be applied to various uſes, as meaſuring the height of towers or mountains; for 12040 inches of air being equal to one inch of mercury, near the ſurface of the earth, 1204 inches, or 100 feet, muſt be equal to one-tenth of an inch of mercury. Conſequently if a barometer be carried up any great eminence, the mercury will deſcend one-tenth of an inch for every 100 feet the barometer aſcends.

But the great uſe of the barometer, when well conſtructed, is that of predicting the future ſtate of the weather, for ſeveral hours, and ſometimes days, preceding; though not to a certainty, yet in many inſtances to a great degree of probability: in order to obtain this deſirable end, obſerve the following rules.

Firſt, The riſing of the mercury preſages in general, fair weather; and its falling, foul weather. 2. In very hot weather, the falling of the mercury foreſhows thunder. 3. In winter the riſing portends froſt; and in a continued froſt it foretells ſnow. 4. When foul weather happens ſoon after the falling of the mercury, expect but little of it; and ſo on the contrary, of fair weather. 5. But when the mercury continues to riſe for ſome time before the foul weather is over, expect a continuance of fair weather to follow. 6. In fair weather, when the mercury continues to fall before rain comes, then expect a great deal of it and probably high winds. 7. The unſettled motion of the mercury denotes uncertain or changeable weather.

It appears from theſe obſervations, that it is not ſo much the height of the mercury that indicates the weather, as its motion up or down. Therefore to know whether the mercury be actually riſing or falling obſerve the following rules. 1. If the ſurface of the mercury be convex, it is then riſing. 2. If the ſurface be concave, it is then ſinking. 3. If the ſuface be plain, or rather a little convex, it may be conſidered as

as ſtationary. If the tube be ſmall, ſhake it, and if the air be growing heavier it will riſe about half the tenth of an inch, and if it be growing lighter it will ſink the ſame ſpace.

The great utility of the common barometer has induced many perſons to invent others, in which the riſe and fall of the mercury, and conſequently the alterations of the atmoſphere, or the height of places, may be more eaſily obſerved; ſuch as the diagonal, the rectangular, the wheel, and pendant barometers, &c. which are in general attended with ſome peculiar advantages and ſome defects. But for general uſe, the common barometer, eſpecially with a Nonius diviſion, is perhaps of all others the moſt eligible.

In ſuch of the following recreations as are performed by the air-pump, it will be ſufficient to have the receiver only in the room where the experiments are made; and to let the pipe, called the ſwan's neck, be carried through the frame of the table on which the receiver ſtands, and communicate with the other parts of the air-pump in an adjoining room, after the ſame manner as in the articles of electricity and magnetiſm.

By this method the recreations will be heightened by the pleaſure of ſurpriſe; a pleaſure that many people find much greater than they are able to expreſs.

RECREATION LVIII.

The bottles broke by air.

TAKE a bottle that is ſquare, not round or cylindrical; and if it be ſmall, the glaſs muſt be thin. Put the mouth of this bottle over the hole in the plate of the air-pump, and exhauſt the air. By this means the bottle will be made to ſuſtain the weight of the external air as long as it is able, but at laſt it will be ſuddenly burſt into very ſmall parts.

The ſame effect may be produced by the ſpring of the air, in the following manner. Seal the mouth of a bottle ſo cloſe that not the leaſt air can come out, and

and place it in the receiver; then as the air is drawn off from its ſurface, the ſpring of the included air will act againſt the ſides of the bottle, and will continually increaſe as the air in the receiver becomes more rarified till at laſt it burſt the bottle in pieces.

A ſimilar effect is produced by laying a plate of glaſs on the top of an open receiver, and exhauſting the air; for then the weight of the external air will preſs upon the glaſs and break it in pieces. In like manner if a perſon lay his hand upon an open receiver, and the air be exhauſted, his hand will be fixed to the receiver: for if the aperture of the receiver be four ſquare inches, the weight on his hand will be equal to 60 pound. This experiment will be attended with ſome pain in the perſon's hand.

RECREATION LIX.

The braſs hemiſpheres.

TAKE two hemiſpheres of about four inches diameter, and whoſe circumferences exactly fit each other. Now when they are placed together, and the air is exhauſted from their cavities, the internal ſpring taken away, they will be preſſed by a column of air equal to their ſurfaces, that is, twelve ſquare inches and a half, which multiplied by fifteen pounds, the weight of the air on every inch, the ſum will be 187 pounds and a half.

Therefore, give theſe hemiſpheres to any two perſons, after they have ſeen them put together, and that they are not in any manner joined to each other, and deſire them to pull the hemiſpheres aſunder; to effect which they muſt, between them, exert a force equal to the above number of pounds.

RECREATION LX.

Water boiled by air.

TAKE water that is made as warm as you can well bear to put your hand in it, but that has not boiled,

and putting it under the receiver exhauſt the air. Bubbles of air will ſoon be ſeen to riſe, at firſt very ſmall, but preſently become larger, and will be at laſt ſo great, and riſe with ſuch rapidity, as to give the water all the appearance of a violent boiling. This agitation of the water will continue till the air is again let into the receiver, when it will immediately ceaſe, and the water become quite motionleſs.

RECREATION LXI.

The aerial bubbles.

TAKE a piece of iron, braſs, ſtone, or any other heavy ſubſtance, and putting it in a large glaſs with water, place it in the receiver. The air being exhauſted, the ſpring of that which is in the pores of the ſolid body, by expanding the particles, will make them riſe on its ſurface in numberleſs globules, which reſembling the pearly drops of dew on the tops of the graſs, afford a very pleaſing appearance. On letting the air into the receiver all theſe aerial forms immediately diſappear.

RECREATION LXII.

The floating ſtone.

TO a piece of cork tie a ſmall ſtone, that will juſt ſink it, and putting it in a veſſel of water, place it under the receiver. Then exhauſting the receiver, the bubbles of air which expand from its pores, and adhering to its ſurface, will render it, together with the ſtone, lighter, than water, and conſequently they will riſe to the ſurface and float.

RECREATION LXIII.

The withered fruit reſtored.

TAKE a ſhriveled apple, and placing it under the receiver exhauſt the air. The apple will immediately be plumped up, and look as fair as when firſt gather-

ed

ed. For the preſſure of the external air being taken off, the expanſion of that contained within the ſkin of the apple will extend it to the utmoſt, ſo as ſometimes to make it burſt. This reſtoration, however, is merely apparent, for the air is no ſooner let into the receiver again than the apple returns to its former withered ſtate.

RECREATION LXIV.

The vegetable air bubbles.

PUT a ſmall branch of a tree with its leaves, or part of a ſmall plant, in a veſſel of water, and placing the veſſel in the receiver, exhauſt the air. When the preſſure of the external air is taken off, the ſpring of that contained in the air veſſels of the plant, by expanding the particles, will make them riſe from the orifices of all the veſſels, for a long time together, and produce a beautiful appearance. This experiment ſhows how great a quantity of air is contained in every vegetable ſubſtance.

RECREATION LXV.

The mercurial rod.

TAKE a piece of ſtick, cut it even at each end with a penknife, and immerſe it in a veſſel of mercury. When the air is pumped out of the receiver, it will at the ſame time come out of the pores of the wood, through the mercury, as will be viſible at each end of the ſtick. When the air is again let into the receiver, it falls on the ſurface of the mercury and forces it into the pores of the wood, to poſſeſs the place of the air.

When the rod is taken out and weighed, it is found to be ſeveral times heavier than before, and has changed its colour, being now all over of a bluiſh hue. If this ſtick be cut tranſverſely, the quickſilver will be ſeen to glitter in every part of it.

RECREATION LXVI.

The myſtical bell.

FIX a ſmall bell to the wire that goes through the top of the receiver, and ſhaking it by that wire it will be diſtinctly heard, while the air is in the receiver. As the air is exhauſted, the ringing becomes gradually weaker, and at laſt, how much ſoever the bell be ſhook, the leaſt ſound cannot be heard. But when the air begins to enter again into the receiver, the ſound becomes preſently audible. This experiment proves that air is the medium of ſound.

RECREATION LXVII.

Feathers heavier than lead.

AT one end of a fine balance hang a piece of lead, and at the other as many feathers as will keep it in equilibrio. Then place the balance under the receiver. As ſoon as the air begins to be exhauſted, the equilibrium will begin to be deſtroyed, and when all the air is exhauſted, the feathers will deſcend and the lead mount up.

The cauſe of this phenomenon is plainly deducible from the laws of hydroſtatics; for when both bodies are weighed in air, each looſes the weight of an equal bulk of air; conſequently the feathers will loſe a greater weight than the lead; but when the air is taken away, the weight that is reſtored to the feathers being greater than that reſtored to the lead, the former will neceſſarily preponderate.

RECREATION LXVIII.

The ſelf-moving wheel.

TAKE a circle of tin about ten inches diameter, or of any other dimenſion that will go into the receiver, and to its circumference fix a number of tin vanes, each about an inch ſquare. Let this wheel be placed, between

tween two upright pieces, on an axis whose extremities are quite small, so that the wheel may turn, in a vertical position, with the least force possible. Place the wheel and axis in the receiver and exhaust the air. Let there be a small pipe with a cock; one end of this pipe is to be on the outside of the top of the receiver, and the other end to come directly over the vanes of the wheel.

When the air is exhausted from the receiver, open the cock just mentioned. A current of air will rush against the vanes of the wheel, and put it in motion; and the velocity of its motion will increase till the receiver is again replete with air.

If the pump be kept continually working, after the air is exhausted, the motion of this wheel may be regarded not only as spontaneous but perpetual.

RECREATION LXIX.

The animated figures.

PROVIDE nine, twelve, or any number you please, of hollow cylinders, about nine inches long, and one and a half, or two inches diameter. Let the bottom of each of these cylinders be closed, except a small hole; and in each of them place a piston, like that in a syringe. At the bottom of each piston let there be a worm spring, and over it the figure of a man, woman, or what else you please. These figures should be all different, and in different attitudes, and of such a size that they may completely enter the cylinders.

Place all the cylinders in a circular frame of wood, and having pushed each piston down to the bottom of the cylinder, and stopped the holes at bottom, draw it up again to what height you think proper, and there will then be a vacuum under each piston. Then place the frame in the receiver, and exhaust the air.

When the weight of the external air begins to be taken off, the force of the spring that is at the bottom of each piston being greater than its friction, and the weight of the figure placed over it, they will all gradually

dually rise up, and present themselves in their proper attitudes. When the air is again let into the receiver, they will in like manner, retire to their separate apartments.

If the arms and legs of the figures be inflated with a due quantity of air, when the pressure of that in the receiver is taken off, they will be extended, and may be made to assume any attitude required: and when the air is again let into the receiver, they will resume their former positions.

RECREATION LXX.

The artificial halo.

PLACE a candle on one side of a receiver, and let the spectator place himself at some distance from the other side. As soon as the air begins to be exhausted, and becomes attenuated and charged with vapours to a proper degree, the light of the candle will be refracted through that medium in circles of various colours, that lively resemble those seen about the moon in a hazy night.

RECREATION LXXI.

The mercurial shower.

CEMENT a piece of wood into the lower part of the neck of an open receiver, and pour mercury over it. After a few strokes of the pump, the pressure of the air on the mercury will force it through the pores of the wood in form of a beautiful shower: which, if the receiver be clear and the weather be dry, will appear luminous in a dark chamber.

RECREATION LXXII.

The fountain in vacuo.

TAKE a tall glass tube, hermetically sealed at the top and at bottom, by means of a brass cap, screwed on to a stop cock, and that to the plate of the pump. When

When all the air is exhauſted the cock is turned, the tube is taken off the plate and immerſed in a baſon of mercury or water: then the cock being again turned, the fluid, by the preſſure of the air, will play up in the tube, in form of a fountain, and afford a very pleaſing appearance.

There are a great number of other experiments performed by the air pump; but theſe are quite ſufficient to explain the nature of the air's preſſure and expanſion, which is their general intention.

RECREATION LXXIII.

The air-gun.

THERE are two ſorts of air-guns, the common, and what is called the magazine air-gun.

The common air-gun is made of braſs, and has two barrels, (Pl. XXIII. Fig. 1.) The inner barrel KA, has a ſmaller bore than the other ECDR. In the ſtock of the gun there is a ſyringe SMNP, by which the air is injected into the cavity, between the two barrels, through the valve NP. The ball K is put down the ſmaller barrel with a rammer, as in other guns. At TL is another valve, which being drawn open by the trigger O, makes way for the air to get behind the ball, and drive it out with great violence. By ſuddenly opening and ſhutting the valve, one charge of condenſed air will ſerve for ſeveral diſcharges, which are effected by means of the lock repreſented in Fig. 2.

In the magazine air-gun there is an additional barrel of a ſerpentine form, which holds ten or twelve balls, that are brought into the ſhooting barrel ſucceſſively, by means of a lever, which is called a hammer.

RECREATION LXXIV.

Artificial rain and hail.

MAKE a hollow cylinder of wood (Plate XXIII. Fig. 3.) let it be very thin at the ſides, about eight or ten inches

inches wide, and two or three feet in diameter*. Divide its inside into five equal parts, by the boards A. of five or six inches wide; and let there be between them and the wooden circle a space B, of about one sixth of an inch. You are to observe that these boards are to be placed obliquely, as in the figure.

In this cylinder put four or five pounds of leaden shot, of a size that will easily pass through the opening you have left. Let it turn on the axis D, and be supported by the foot C.

The sound of this machine when in motion, will strongly represent that of rain, and will increase with the velocity of the motion. To produce the sound of hail, a larger sort of shot must be used.

RECREATION LXXV.

The magical flowers and fruit.

MAKE a box ABCD, (Plate XXIII. Fig. 4.) of about six inches every way. In the middle of the top AB, let there be a hole, through which is to pass the neck of the vessel E, that is a kind of hollow copper sphere, of three or four inches diameter, and covered at its top and bottom F and G, with two pieces of the same metal, they are to be well soldered to it. To the part next F there is to be soldered the tube H, about half an inch in diameter, through which is an aperture of a quarter of an inch: this tube must also be pierced horizontally, by an opening of one-third of an inch at I, to admit a cock, the key of which must extend to the outside of the case; it should also have a small aperture of about one-tenth of an inch, to let out the air that is to be compressed in the vessel E, as we shall now explain.

To force the air into the hollow vessel there must be adjusted to one of its sides the copper syringe NM, Fig. 5, which has a leather valve at M, and another at its extremity N: that by alternately thrusting in and drawing

* When this machine is intended for a theatre it must be constructed much larger.



Fig. 2.

Fig. 3.



Fig. 4.

Fig. 5.



ing out of the piſton, the air may be ſtrongly condenſed in the veſſel E.

To the extremity of the tube H there is to be fixed the little tree O, which is compoſed of four or five fine branches of copper P, Q, R, S, that proceed from the trunk O. Theſe branches are to be hollow from one end to the other, that the air which enters at the bottom may extend itſelf to the top. To theſe branches are to be adjuſted twigs, made of braſs wire, and the whole is to be decorated with orange leaves, that are made of parchment, and ſtrongly imitate thoſe of nature.

The end of each of the branches is to dilate, ſo that they may contain very ſmall pieces of very fine leather, which are to take the figure of an orange, when they are extended by the air drove through the branches. Theſe leathers muſt de contained within the extremities of the branches, to which they are to be faſtened by a ſilk thread: and there muſt be a ſpace left at the end of the branch, to which is to be fixed the bud or flower of a blowing orange.

The trunk of the orange-tree muſt exactly fit the tube H, that none of the air may eſcape; and it is to be made to take out. The branches and the leathers that are to form the oranges muſt be accurately painted, to favour the illuſion. There ſhould be a glaſs cover to the whole, which will prevent any one from touching it; and the top of the box may be covered with earth.

Previous to the performing this Recreation you take the orange tree out of the caſe, and with a little ſtick made for that purpoſe, you put each of the oranges within the end of the branch, together with the flowers of the blowing oranges; ſo that no part of them may appear: and the better to conceal them, the greateſt number of leaves may be at the ends of the branches. The tree is then to be replaced in the tube H. You are next to turn the cock at I, and with the ſyringe throw a ſufficient quantity of air into the veſſel E.

Matters being thus prepared, you introduce the box and tree covered with the glaſs; and make the company

pany obſerve, that in its preſent ſtate it bears neither flowers or fruit, and tell them if it be their pleaſure it ſhall inſtantly produce both. You then turn the cock*, when the flowers or buds will immediately appear, and will be ſucceeded by the fruit.

This Recreation may be performed by putting an eolipile in the box inſtead of the copper veſſel; under which you place a chafing-diſh with hot coals, that is to be ſuppoſed to produce the ſudden vegetation in the tree. The air in the eolipile being rarified by the heat will produce the ſame effect as the condenſed air in the other veſſel.

HYDRO-

* This cock ſhould be ſo concealed that you may turn it without being obſerved by the company.

HYDROLOGY.

DEFINITIONS.

1. HYDROLOGY is that part of phiſiology which explains the properties of water. It is uſually divided into hydroſtatics and hydraulics; the former of which treats of the manner of weighing water, and fluids in general, and of aſcertaining their ſpecific gravities, that is their particular weights; and the other ſhows the manner of conveying water from one place to another*.

2. A ſiphon is a bended tube, commonly of a form nearly reſembling half an ellipſis.

3. A valve is a ſort of flap or cover, fixed to a pipe or other body, which by opening one way only, ſuffers the water to paſs, but not to return.

4. A piſton is a ſmall cylinder faſtened to the end of a rod, and fitted to the bore of a pipe or hollow cylinder, and frequently contains a valve.

5. The hydrometer is an inſtrument conſtructed to find the ſpecific gravities of fluids.

6. The hydroſtatic balance is contrived to ſhow the ſpecific gravities of fluids and of ſolids, by weighing them in fluids.

APHORISMS.

1. Water is a ſcentleſs, tranſparent, colourleſs fluid†, which, with a certain degree of cold, turns to ice.

2. Water is one of the conſtituent parts of all bodies‡.

3. All

* The term hydroſtatics is frequently uſed for a general treatiſe on water, but certainly with impropriety.

† Though fluidity be commonly regarded as an eſſential property of water, yet many philoſophers, particularly Boyle and Boerhaave, conſider it as an adventitious circumſtance, produced by a certain degree of heat, and aſſert its natural ſtate to be that of a cryſtalline, as when in ice.

‡ This is proved by diſtillation, for the dryeſt woods, earths, bones, and ſtones pulveriſed, conſtantly yield a certain quantity of water.

3. All fluids, except air, are incompreſſible*.

4. Though water is leſs diaphanous than air, it is more penetrative, as it will pervade bodies that air will not.†

5. Water diſſolves ſome bodies, as ſalts, and conglutinates others, as bricks, ſtones, bones, &c.

6. Water in its natural ſtate, contains the three other elements, fire, earth, and air‡.

7. The water, in ſeveral tubes that communicate with each other, will ſtand at the ſame height in all of them, whether they be ſmall or great, perpendicular or oblique.

8. The ſurface of water contained in a veſſel will always be even, and parallel to the horizon§.

9. In a veſſel of water the preſſure of the upper on the lower parts, is in proportion to the depth; and is the ſame at the ſame depth, whatever be the diameter of the veſſel.

10. The preſſure of a fluid upward is equal to its preſſure downward, at any given depth‖.

11. The

water. It has been found by experiment, that the water contained in a certain quantity of air was nearly equal to the air itſelf.

* If a globe of gold be filled with water, and preſſed with a very great weight, the water will tranſude the pores of the gold, and cover the ſurface of the globe, in the form of a fine dew. This is called the Florentine experiment.

† This is evident from its paſſing through the pores of a bladder.

‡ We have already ſaid that water owes its fluidity to heat, and it is evident from many experiments with the air-pump, that it contains no ſmall quantity of air: and the ſediment that is found in all water, except that which is diſtilled, always contains a quantity of earth.

§ In large bodies of water, as the ſea, or great lakes, the ſurface will not be plain, but ſpherical, as making a part of the ſurface of the terraqueous globe.

‖ It follows from this and the preceding aphoriſm, that the lighteſt ſolid may be ſunk in the heavieſt fluid, as cork in quickſilver, and will remain at the bottom, if it be ſo contrived that none of the fluid can get under it. On the contrary, the heavieſt ſolid may be ſuſpended in the lighteſt fluid; if the fluid be of a ſufficient depth, and be prevented from preſſing on the top of the ſolid.

11. The bottom and ſides of a veſſel are preſſed by the fluid it contains in proportion to its height, without any regard to the quantity.

12. If fluids of different gravities be contained in the ſame veſſel, the heavieſt will be at bottom, the lighteſt at top, and the reſt in proportion to their ſpecific gravities.

13. A body that is heavier than an equal quantity of any fluid will ſink in that fluid; if it be lighter, it will ſwim at the top; but if it be of the ſame gravity, it will neither ſink nor ſwim, but remain ſuſpended in any part of that fluid.

14. A ſolid immerſed in a fluid is preſſed by that fluid on all ſides, in proportion to the height of the fluid above the ſolid. Bodies very deeply immerged may be conſidered as equally preſſed on all ſides.

15. Every ſolid immerſed in a fluid, loſes ſo much of its weight, as is equal to a weight of a quantity of that fluid of the ſame dimenſion with the ſolid*.

16. The fluid acquires the weight the ſolid loſes.

ſolid. This is commonly proved by putting a guinea in a tube, exactly of the ſame diameter, and holding it to the bottom by means of a ſtring. Then, as gold is about nineteen times heavier than water, if you put the tube down in the water to about nineteen times the thickneſs of the guinea, and let the ſtring go, the guinea will not ſink, but be ſuſtained by the preſſure of the water under it, which is there greater than the gravity of the guinea.

* It is on this aphoriſm that the hydroſtatic balance is founded: for every ſolid, on being immerſed in a fluid, loſes ſo much of its weight as is equal to the weight of an equal bulk of that fluid, it follows that the lighter the body is, the greater proportion of its weight it will loſe; therefore, if two bodies of equal bulk be firſt weighed in air, and then in water, and it be found that one has loſt half of its weight, and the other one-fourth, it follows that the ſpecific gravity of the latter is to that of the former as 2 to 1. From hence alſo is derived the method of finding the ſpecific gravity of fluids, for if the ſame ſolid when weighed in two different fluids, loſes twice as much in one as in the other, it follows that the ſpecific gravity of the former muſt be twice as great as that of the latter.

THE HYDROLOGIC APPARATUS.

AMONG the hydrologic apparatus, the ſyphon claims the firſt regard, and that as well from its ſimplicity, as its utility in explaining the more complex machines.

If the ſyphon EFG (Pl. XXIV. Fig. 1.) be immerſed in the veſſel of water ABCD, and the air ſucked out at E*, the preſſure of the air upon the ſurface of the water in the veſſel will force it up the vacuity in the pipe from G, and paſſing through the top in at F, it will deſcend in the other leg, and run out at E, as long as the ſurface of the water is above the bottom of the leg CG. You muſt obſerve, however, that to make the water run out, the end E of the ſyphon muſt be below G: for if both ends be parallel, the preſſure of the air on each end will be equal, and the water will remain in the ſyphon.

It is to be remembered, that the top of the ſyphon muſt not exceed 32 feet perpendicular altitude above the ſurface of the water in the veſſel; for a column of air of the height of the atmoſphere is but juſt equal to a column of water of 32 feet. Mercury may be drawn through a ſypon in the ſame manner, as water; but then the utmoſt height of the ſyphon muſt always be leſs than 30 inches, as mercury is near 14 times heavier than water. That fluids are forced through the ſyphon by the preſſure of the atmoſphere is proved experimentally by the air-pump; for if a ſyphon immerſed in a veſſel of water be placed, when running, in the receiver, and the air extracted, the running will immediately ceaſe.

There is a ſort of ſyphon that will draw off water without having the air previouſly extracted from it: this conſiſts of a capillary tube, about one tenth of an inch bore, and acts by the attraction of cohefion: for the

* If the ſyphon or crane be filled with water, then inverted, and one end placed in a veſſel of water, it will have the ſame effect as drawing out the air, and when the ſyphon is large, will be more eaſily effected.

Fig. 1.

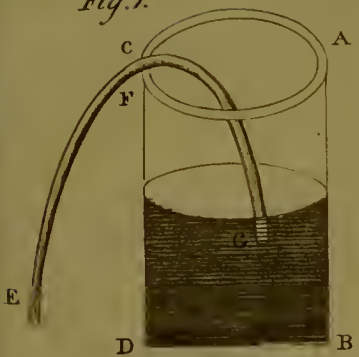


Fig. 2.



Fig. 3.

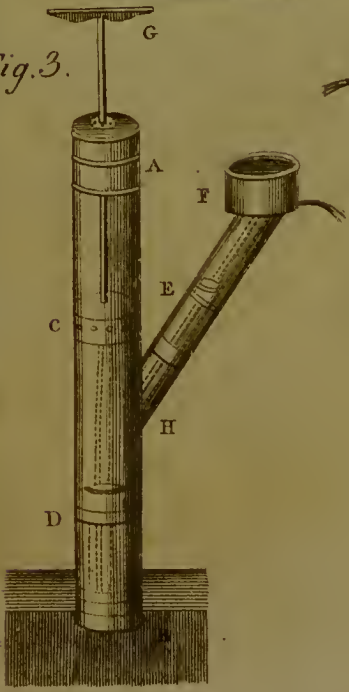
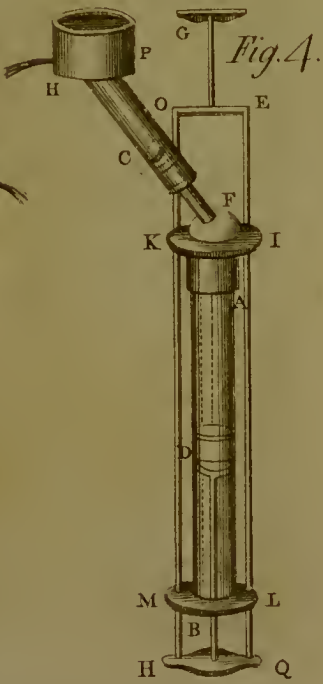


Fig. 4.



the water being attracted by the leg immerſed, is ſlowly drawn up to the top of the ſyphon, and from thence gradually deſcends by its gravity. From the ſame cauſe it is, that if one end of a piece of the liſt of cloth be put in the water of a veſſel, and the other end hang over its ſide, the water will be ſucked up by the end of the liſt, in the veſſel, which in this caſe acts as a bundle of very fine capillary tubes, and drop from the other end. This experiment with a capillary tube will ſucceed in vacuo.

THE PUMP.

THE pump is at once the moſt common and moſt uſeful of all hydraulic inſtruments. Of pumps there are three ſorts, the ſucking, forcing and lifting pump.

AB (Plate XXIV. Fig. 2) is the pipe or barrel of a common ſucking pump, CD the piſton or bucket, EF two valves that open upward. When the handle of the pump is put down it raiſes the bucket, and the valve F ſhuts. The water above the bucket being raiſed, a vacuum is left under it, and the external air preſſing on the water in the well MN, raiſes it up, through the hole B, and lifting up the valve E, enters the barrel of the pump. The handle of the pump being then raiſed, the bucket deſcends, the valve F opens, and lets the water deſcend above the bucket. The preſſure of the water at the ſame time ſhuts the valve E, ſo that it cannot return through B. The handle being again preſſed down, the bucket is again raiſed, and more water aſcends through B. So that at every ſtroke of the handle, the water in the barrel is increaſed, till at laſt it runs out at the pipe H.

If the bucket be more than 30 or 32 feet from the ſurface of the water in the well, it will not aſcend to the bucket, for the preſſure of the atmoſphere, as we have before obſerved, is but equal to 32 feet of water. The weight the bucket lifts at each ſtroke, is equal to a column of water whoſe diameter is that of the bore of the pump and its height MH. It is therefore of no conſequence where the bucket is placed, with regard to the weight of water. To balance that weight the

handle ſhould be made heavy. The piſton or bucket muſt be ſurrounded with leather, that it may exactly fit the bore of the pump, at the ſame time it moves freely up and down. The valves alſo ſhould move free and ſhut quite cloſe. The ſmaller the bore of the pump, the eaſier it will work; but the wider it is, and the longer the ſtroke of the handle, the more water it will raiſe.

The forcing pump is conſtructed as follows: AB (Pl XXIV. Fig. 3.) is the barrel ſtanding in the water of the well at B. C is the piſton, and G the handle: C is a ſolid piece, without any valve, as no water is to paſs through it: this piece ſhould be carefully leathered, and made to fit the barrel ſo exactly, that in its motion neither water nor air may paſs between them. At a diſtance below, as at D, a valve is fixed. Between this and the loweſt ſituation of the piſton C, there goes off a pipe H, in which is fixed a valve at E.

Now the piſton being drawn up from C towards A, exhauſts or rarefies the air above D, which cauſes the water to ruſh into the ſpace CD; and when the piſton is forced down, as the water cannot repaſs at D, it is forced to aſcend into the pipe H, and through its valve E into the ciſtern F (which may be placed at any diſtance from the pump) and from thence it runs off by the ſpout.

Of lifting pumps there are ſeveral ſorts; the moſt common is thus conſtructed. AB (Pl. XXIV. Fig. 4.) is the barrel, fixed in the frame KILM; which is alſo fixed immoveable, with the lower part in the water that is to be pumped up. GEQHO is a frame with two ſtrong iron rods, moveable through holes in the upper and lower parts of the pump, IK and LM. In the bottom of this frame is fixed an inverted piſton BD, with its bucket and valve uppermoſt at D. From the top of the barrel there goes off a part KH, either fixed to the barrel, or moveable by a ball and ſocket (as here repreſented at F), but in either caſe ſo very exact and tight, that no water or air can poſſibly get into the barrel, as that would prevent the effect of the pump.

pump. In this part, at C, is fixed in a valve opening upward.

When the piſton frame is thruſt down into the water, the piſton D will deſcend, and the water beneath it ruſh up through the valve at D, and get above the piſton; where, upon the frames being lifted up, the piſton will force the water through the valve C, into the ciſtern P, there to run off the ſpout. It is to be remembered, that this ſort of pump muſt be ſet ſo far in the water, that the piſton may play below its ſurface. It appears by the above deſcription, that this is only a different manner of conſtructing a forcing pump.

THE HYDROMETER.

THIS is the moſt eligible of all inſtruments for finding the ſpecific gravity of fluids only, as well for eaſe as expedition.

The globe of the hydrometer ſhould be made of copper, for ivory imbibes ſpiritous liquors, and thereby alters their gravity, and glaſs requires an attention that is incompatible with expedition. The moſt ſimple hydrometer conſiſts of a copper ball, B *b* (Plate XXV. Fig. 1.) to which is ſoldered a braſs wire AB, one quarter of an inch thick. The upper part of this wire being filed flat is marked *proof*, at *m*, Fig. 2. becauſe it ſinks exactly to that mark in proof ſpirits. There are two other marks at A and B, Fig. 1, to ſhew whether the liquor be one tenth above or below proof, according as the hydrometer ſinks to A, or emerges to B, when a braſs weight, as C or K, is ſcrewed to its bottom *c*. There are other weights to ſcrew on, which ſhew the ſpecific gravity of different fluids, quite down to common water.

The round part of the wire above the ball, may be marked ſo as to repreſent river water when it ſinks to RW, Fig. 2, the weight which anſwers to that water being then ſcrewed on; and when put into ſpring water, mineral water, ſea water, and water of ſalt ſprings, it will gradually riſe to the mark SP, MI, SE, SA. On the contrary, when it is put into Briſtol water,

rain water, port wine, and mountain wine, it will successively sink to the marks *br*, *ra*, *po*, *mo*. Instruments of this kind are some times called areometers.

There is another sort of hydrometer that is calculated to ascertain the specific gravity of fluids to the greatest precision possible, and which consists of a large hollow ball B (Pl. XXV. Fig. 3.) with a smaller ball *b* screwed on to its bottom, partly filled with mercury or small shot, in order to render it but little specifically lighter than water. The larger ball has also a short neck at C, into which is screwed the graduated brass wire AC, which by a small weight at A, causes the body of the instrument to descend into the fluid, with part of the stem.

When this instrument is swimming in the liquor contained in the jar ILMK, the part of the fluid displaced by it, will be equal in bulk to the part of the instrument under water, and equal in weight to the whole instrument. Now, suppose the weight of the whole to be four thousand grains, it is then evident we can by this mean compare the different dimensions of four thousand grains of several sorts of fluids. For if the weight at A, be such as will cause the ball to sink in rain water, till its surface comes to the middle point of the stem 20, and after that if it be immersed in common spring water, and the surface be observed to stand at one-tenth of an inch below the middle point 20, it is apparent that the same weight of each water, differs only in bulk by the magnitude of one-tenth of an inch in the stem.

Now suppose the stem to be ten inches long, and weight a hundred grains, then every tenth of an inch will weigh one grain; and as the stem is of brass, which is about eight times heavier than water, the same bulk of water will be equal to one-eighth of a grain and consequently to the one-eighth of one four thousandth part, that is, one thirty-two thousandth part of the whole bulk. This instrument is capable of still greater precision, by making the stem or neck consist of a flat thin slip of brass, instead of one that is cylindrical:

lindrical: for by this mean we increaſe the ſurface, which is the moſt requiſite circumſtance, and diminiſh the ſolidity, which neceſſarily renders the inſtrument ſtill more accurate.

To adapt this inſtrument to all purpoſes, there ſhould be two ſtems, to ſcrew on and off, in a ſmall hole at *a*. One ſtem ſhould be a ſmooth thin ſlip of braſs, or rather ſteel, like a watch-ſpring ſet ſtraight, ſimilar to that we have juſt mentioned, on one ſide of which is to be the ſeveral marks or diviſions to which it will ſink in different ſorts of water; as rain, river, ſpring, ſea, and ſalt ſpring waters, &c. and on the other ſide you may mark the diviſions to which it ſinks in various lighter fluids, as hot Bath water, Briſtol water, Lincomb water, Cheltenham water, port wine, mountain, madeira, and other ſorts of wines. But here the weight at A on the top muſt be a little leſs than before, when it was uſed for heavier waters.

But in trying the ſtrength of the ſpiritous liquors a common cylindric ſtem will do beſt, becauſe of its ſtrength and ſteadineſs: and this ought to be ſo contrived, that when immerſed in what is called proof ſpirit, the ſurface of the ſpirit may be upon the middle point 20: which is eaſily done by duly adjuſting the ſmall weight A, on the top, and making the ſtem of ſuch a length, that when immerſed in water, it may juſt cover the ball and riſe to *a*; but when immerſed in pure ſpirit, it may riſe to the top A. Then by dividing the upper and lower parts *a* 20 and A 20, into ten equal parts each, when the inſtrument is immerſed in any ſort of ſpiritous liquor it will immediately ſhow how much it is above or below proof.

Proof ſpirit conſiſts of half water, and half pure ſpirit, that is, ſuch as when poured on gunpowder, and ſet on fire will burn all away: and permits the powder to take fire and flaſh as in open air. But if the ſpirit be not ſo highly rectified, there will remain ſome water, which will make the powder wet, and unfit to take fire. Proof ſpirit of any kind, weighs ſeven pounds twelve ounces per gallon.

The

The common method of ſhaking the ſpirits in a phial, and raiſing a head of bubbles, to judge by their manner of riſing or breaking whether the ſpirit be proof, or near it, is very fallacious. There is no way ſo certain, and at the ſame time ſo eaſy and expeditious, as this by the hydrometer: which will infallibly demonſtrate the difference of bulks, and conſequently the ſpecific gravities in equal weights of ſpirits, to the thirty, forty, or fifty thouſandth part of the whole, which is a degree of accuracy no one can wiſh to exceed.

THE HYDROSTATIC BALANCE.

THOUGH the hydrometer is the moſt convenient inſtrument for meaſuring the ſpecific weights of fluids, yet for a meaſure of the ſpecific gravity of all ſubſtances, we muſt have recourſe to the hydroſtatic balance; which is conſtructed in various forms, but we ſhall content ourſelves here with deſcribing that which appears of all others the moſt accurate.

V C G, (Pl. XXV. Fig. 4.) is the ſtand or pillar of this hydroſtatic balance, which is to be fixed in a table. From the top A, hangs, by two ſilk ſtrings, the horizontal bar B B, from which is ſuſpended by a ring *i*, the fine beam of a balance *b*; which is prevented from deſcending too low on either ſide by the gentle ſpringing piece *l x y z*, fixed on the ſupport M. The harneſs is anulated at *o*, to ſhew diſtinctly the perpendicular poſition of the examen, by the ſmall pointed index fixed above it.

The ſtrings by which the balance is ſuſpended, paſſing over pullies, one on each ſide the piece at A, go down to the bottom on the other ſide, and are hung over the hook at *v*; which hook, by means of a ſcrew P, is moveable, about one inch and a quarter, backward and forward, and therefore the balance may be raiſed or depreſſed ſo much. But if a greater elevation or depreſſion be required, the ſliding piece S, which carries the ſcrew P, is readily moved to any part of the ſquare braſs rod VK, and fixed by means of a ſcrew.

The

Fig. 1.



Fig. 2.

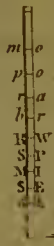


Fig. 3.

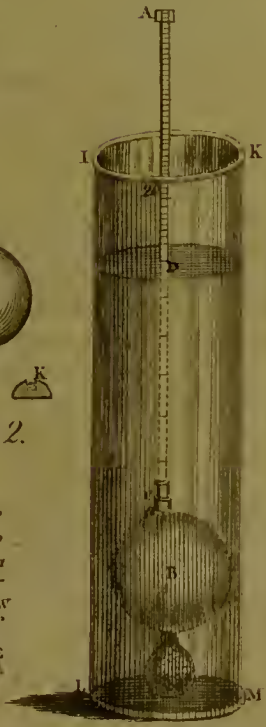
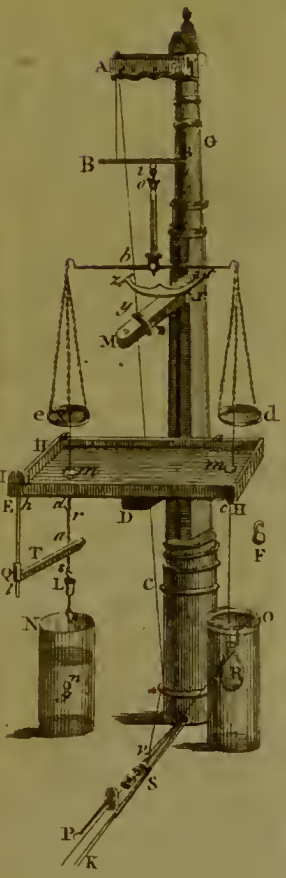


Fig. 4.



The motion of the balance being thus adjusted, the rest of the apparatus is as follows. H H is a small board, fixed upon the piece D, under the scales *d* and *e* and is moveable up and down in a long slit in the pillar, above C, and fastened at any part by a screw behind. From the point in the middle of the bottom of each scale hangs, by a fine hook, a brass wire *a d*, and *a c*. These pass through two holes *m m*, in the table. To the wire *a d* is suspended a curious cylindric wire *r s*, perforated at each end for that purpose: this wire *r s* is covered with paper, graduated by equal divisions, and is about five inches long.

In the corner of the board at E, is fixed a brass tube, on which a round wire *h l* is so adapted as to move neither too tight nor too free, by its flat head I. Upon the lower part of this moves another tube Q, which has sufficient friction to make it remain in any position required: to this is fixed an index T, moving horizontally when the wire *h l* is turned about, and therefore may be easily set to the graduated wire *r s*. To the lower end of the wire *r s* hangs a weight L, and to that a wire *p n*, with a small brass ball *g*, about one-fourth of an inch diameter. On the other side, to the wire *a c*, hangs a large glass bubble R, by a horse hair.

Let us first suppose the weight L taken away, and the wire *p n* suspended from S; and on the other side, let the bubble R be taken away, and the weight F suspended at *c* in its room. This weight F we suppose to be sufficient to keep the several parts hanging to the other scale in equilibrio; at the same time that the middle point of the wire *p n* is at the surface of the water in the vessel N. The wire *p n* is to be of such a size that the length of one inch shall weigh four grains.

Now it is evident, since brass is eight times heavier than water, that for every inch the wire sinks in the water it will become half a grain lighter, and half a grain heavier for every inch it rises out of the water: consequently, by sinking two inches below the middle point, or raising two inches above it, the wire will become

come one grain lighter or heavier. Therefore, if when the middle point is at the surface of the water in equilibrio, the index T, be set to the middle point *a*, of the graduated wire *r s*, and the distance on each side *a r* and *a s* contains a hundred equal parts, then, if in weighing bodies the weight is required to the hundreth part of a grain, it may be easily had by proceeding in the following manner.

Let the body to be weighed be placed in the scale *d*. Put the weight X in the scale *e*, and let this be so determined, that one grain more shall be too much, and one grain less, too little. Then the balance being moved gently up and down, by the screw P, till the equilibrium be nicely shewn at *o*; if the index T be at the middle point *a* of the wire *r s*, it shews that the weights put into the scale *e* are just equal to the weight of the body. By this method we find the absolute weight of the body: the relative weight is found by weighing it hydrostatically in water as follows.

Instead of putting the body into the scale *d*, as before, let it hang with the weight F, at the hook *c*, by a horse-hair, as at R, supposing the vessel O of water taken away. The eqilibrium being then made, the index T standing between *a* and *r*, at the thirty-sixth division, shews the weight of the body put in to be 109,536 grains. As it thus hangs, let it be immersed in the water of the vessel O, and it will become lighter: the scale *e* will descend till the beam of the balance rest on the support *z*. Then suppose a hundred grains put into the scale *d* restore the equilibrium precisely, so that the index T stands at the thirty-sixth division above *a*: it is evident that the weight of an equal bulk of water would, in this case be exactly a hundred grains.

After a like manner this balance may be applied to find the specific gravity of liquids, as is easy to conceive from what has been said.

THE

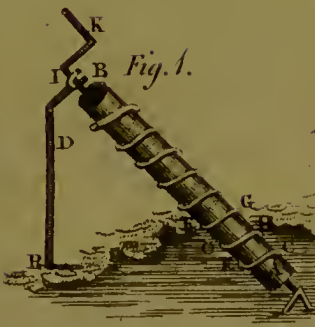


Fig. 1.



Fig. 2.

Fig. 3.

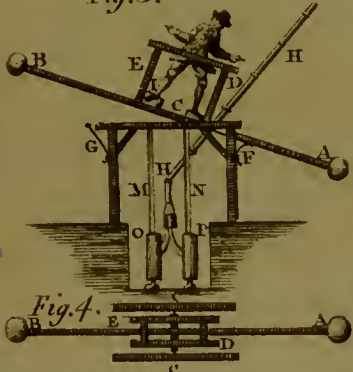


Fig. 4.

Fig. 5.



THE SCREW OF ARCHIMEDES.

THIS is a ſort of ſpherical pump, and receives its name from its inventor. It conſiſts of a long cylinder AB (Pl. XXVI. Fig. 1.) with a hollow pipe CD round it: and is placed in an oblique poſition, with the lower end in the water, the other end being joined to the lower end of the winch IK, ſupported by the upright piece IR.

When this ſcrew is immerſed in the water, it immediately riſes in the pipe, by the orifice C, to a level with the ſurface of the water EF, and if the point in the ſpiral, which in the beginning of the motion is coincident with the ſurface of the water, happen not to be on the lowerſide of the cylinder, the water upon the motion of the ſcrew, will move on in the ſpiral, till it come to the point on the other ſide that is coincident with the water. When it arrives at that point, which we will ſuppoſe to be O, it cannot afterwards poſſeſs any other part of the ſpiral than that on the loweſt part of the cylinder: for it cannot move from O towards H or G, becauſe they are higher above the horizon; and as this will be conſtantly the caſe, after the water in the ſpiral has attained the point O, it is plain it muſt always be on the under ſide of the cylinder.

But becauſe the cylinder is in conſtant motion, every part of the ſpiral ſcrew, from O to D, will by degrees ſucceed to the under part of the cylinder. The water therefore muſt ſucceed to every part of it, from O to D, as it comes on the lower ſide, that is, it muſt aſcend on the lower part of the cylinder, through all the length of the pipe, till it come to the orifice at D, where it muſt run out, having nothing further to ſupport it.

THE BALANCE PUMPS.

THIS is a ſimple and eaſy method of working two pumps at once, by means of the balance AB, (Plate XXVI. Fig. 3.) Having a large iron ball at each end, and

and placed in equilibrio on the two ſpindles C, as repreſented in the 4th figure. On the right and left are two boards I, nailed to the two croſs-pieces, faſtened to the axis of the machine. On theſe boards the perſon who is to work the pump ſtands, and ſupports himſelf by a croſs piece, nailed to the two poſts ED, Fig. 3. At the diſtance of ten inches on each ſide the axis, are faſtened the piſton rods M N.

The man, by leaning alternately on his right and left foot, puts the balance in motion by which the pumps O P, are worked, and the water thrown into the pipe H, and carried to a height proportional to the diameter of the valves, and the force of the balance. There muſt be placed on each ſide an iron ſpring, as F and G, to return the balance, and prevent its acquiring too great velocity.

THE HYDRAULIC SCOOP.

THIS machine conſiſts of five pieces of board, forming a ſort of ſcoop as B, (Plate XXVI. Fig. 2.) The handle C is ſuſpended by a rope, faſtened to three poles, placed in a triangle, and tied together at A.

The working of this machine conſiſts entirely in balancing the ſcoop that contains the water, and directing it in ſuch a manner that the water may be thrown in any given direction. It is evident that the operation of both this and the laſt machine is ſo very eaſy, that it may rather be conſidered as an agreeable and ſalutary recreation, than hard labour.

With this machine a man of moderate ſtrength, by two ſtrokes in four ſeconds, can draw half a cubic foot of water, that is, more than four hundred cubic feet in an hour.

This machine is frequently uſed by the Dutch in emptying the water from their dykes.

RECREA-

RECREATION LXXVI.

The hydroſtatic bellows.

LET AB and EF, (Pl. XXVI. Fig. 5.) be two circular boards of oak: the ſides AE and BF are to be of leather, and joined very cloſe to the top and bottom by ſtrong nails. CD is a pipe ſcrewed into a piece of braſs on the top board, at C.

Now if a man blow into the pipe DC, he may raiſe a very heavy weight placed on the top of the bellows. Or if he ſtand on the top AB, he will, by blowing ſtrongly into the pipe, ſoon blow himſelf up.

If water be poured in at D, till the bellows and pipe be full, the preſſure againſt A B, on the inſide, will lift as much weight on the top, as is equal to a cylinder of water, whoſe baſe is A B, and its height C D.

RECREATION LXXVII.

The water clock.

PROVIDE a cylindric veſſel of glaſs, or china, A BCD (Pl. XXVII. Fig. 1.) about a foot high, and four inches diameter. Make a hole in its bottom, in which glue a ſmall glaſs tube E, of about one-third of an inch diameter, and whoſe end has been partly cloſed in the flame of a lamp, ſo that it will not ſuffer the water to paſs out but by drops, and that very ſlowly. Cover the top of the veſſel with a circle of wood F, in the center of which make a round hole about half an inch diameter.

Have a glaſs tube GH, a foot high, and a quarter of an inch diameter, and at one end let it have a ſmall glaſs globe I, to which you may hang a weight L, by which it is kept in equilibrio, on or near the ſurface of the water; or you may pour a ſmall quantity of mercury into the tube, for the ſame purpoſe. Fill the veſſel with water; put the tube in it; and over it place the cover F, through the hole of which the tube muſt

paſs freely up and down. Now, as the water drops gradually out of the veſſel, the tube will continue to deſcend till it come to the bottom.

Therefore, paſte on the tube a graduated paper, and put it in the veſſel when nearly full of water. Hang a watch by it, ſet to a certain hour, and as the tube deſcends, mark the hours, with the half and quarter hours. If the veſſel be ſufficiently large, with regard to the hole at the bottom, it will go for twelve hours, a day, or as much longer as you pleaſe, and requires no other trouble than that of pouring in water to a certain height. Care muſt be had however that the water be clean, for if there be any ſediment it will in time ſtop the ſmall hole at bottom, or at leaſt render the motion of the water irregular.

The veſſel may be of tin, but the pipe at bottom ſhould be glaſs, that its ſmall aperture may not alter by uſe. It is to be obſerved, that the tube of one of theſe clocks is not to be graduated by another, for though the veſſel be of the ſame diameter at top, it may not be perfectly cylindrical throughout; nor is it eaſy to make the hole at the bottom of one veſſel exactly of the ſame dimenſion with that of another.

RECREATION LXXVIII.

The globular fountain.

MAKE a hollow globe A, (Pl. XXVII. Fig. 4) of copper or lead, and of a ſize adapted to the quantity of water that comes from the pipe to which it is to be placed. Pierce a number of ſmall holes through this globe, that all tend toward its center *. Annex to it a pipe B, of ſuch height as you think convenient, and let it be ſcrewed at C, to the pipe from whence the jet flows.

The water that comes from the jet ruſhing with violence into the globe, will be forced out at the holes, with

* The diameters of all theſe holes, taken together, muſt not exceed that of the pipe at the part from whence the water flows.

Fig. 1.



Fig. 2.



Fig. 4.



Fig. 5.



Fig. 3.

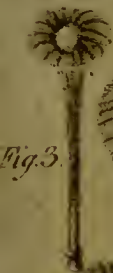
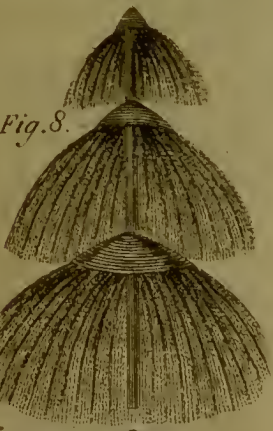


Fig. 8.



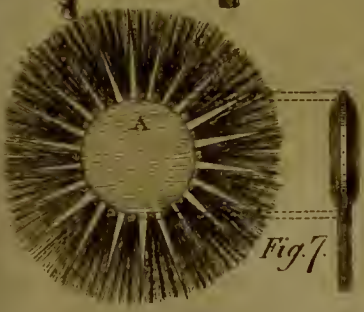
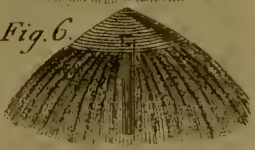


Fig. 7.

Fig. 6.



with the direction in which they are made, and will produce a very pleasing sphere of water.

RECREATION LXXIX.

The hydraulic dancer.

PROCURE a little figure, made of cork, as AB, (Pl. XXVII. Fig. 2.) which you may paint or dress in a light stuff, after your own fancy. In this figure you are to place the small hollow cone C, made of thin leaf brass.

When the figure is placed on the jet-d'eau that plays in a perpendicular direction, it will remain suspended on the top of the water, and perform a great variety of motions.

If a hollow ball of copper, of an inch diameter, and very light, be placed on a similar jet, it will in like manner, remain suspended, revolving on its center, and spreading the water all round it, in the manner represented by Fig. 3.

RECREATION LXXX.

The hemispherical cascade.

MAKE a hollow leaden cone A, (Pl. XXVII. Fig. 5.) whose axis is one third of the diameter of its base. The circle C, that forms the base must be in proportion to the surface of water that flows from the jet on which it is to be placed, that it may flow from it equally on all sides. To the cone join the pipe B, which serves not only as a support, but is to be pierced with a number of holes, that it may supply the cone with a sufficient quantity of water. Screw the tube just mentioned to the top of that from whence the jet proceeds.

The water that rushes into the cone from the pipe, will run over its circumference, and form a hemispherical cascade. If this piece be so constructed that it may be placed in a reversed position, it will produce a fountain in the form of a vase, (see Fig. 6.) and if there be a sufficient quantity of water, both these pieces

may be placed on the ſame pipe. The fountain at top and the caſcade underneath; which by their variety, will produce a very pleaſing appearance.

RECREATION LXXXI.

The water ſun.

LET there be two portions of a hollow ſphere, (Pl. XXVII. Fig. 7.) that are very ſhallow: and let them be ſo joined together, that the circular ſpace between them may be very narrow. Fix them vertically to a pipe from whence a jet proceeds. In that part by which the portions of the ſphere are joined, there muſt be made a number of holes; then the water ruſhing into the narrow cavity will be forced out from the holes, and produce a regular figure of the ſun, as in the plate. This piece requires a large quantity and force of water, to make it appear to advantage.

Several pieces of this ſort may be placed over each other, in a horizontal direction, and ſo that the ſame pipe may ſupply them all with water, (ſee Fig. 8.) It is proper to obſerve, that the diameter of theſe pieces muſt continually diminiſh, in proportion to their diſtance from the bottom.

RECREATION LXXXII.

The revolving water ſun.

MAKE a hollow circle A, (Plate XXVIII. Fig. 1.) the ſides of which are to be pierced with nine, twelve, or fifteen holes, made in an inclined direction: or you may place the like number of ſmall tubes round the circle. Fix this circle on the top of a jet, in ſuch manner that it may turn freely round.

The water ruſhing violently into the hollow circle will keep it in continual motion; and at the ſame time forcing itſelf out of the holes or ſmall tubes, will form a revolving figure, with rays in different directions, as in the plate.

RECREA-

RECREATION LXXXIII.

The phial of the four elements.

TAKE a phial ſix or ſeven inches long, and about three quarters of an inch diameter. In this phial firſt put glaſs groſsly powdered: ſecondly, oil of tartar per diliquum; thirdly, tincture of ſalt of tartar; and fourthly diſtilled rock oil.

The glaſs and the different liquors being of different denſities, if you ſhake the phial, and then let it reſt for a few moments, the three liquors will entirely ſeparate, and each one aſſume its proper place, according to its ſpecific gravity. The powdered glaſs at the bottom of the phial may be ſuppoſed to repreſent earth; the oil of tartar, which occupies the ſecond place, repreſents water: the tincture that floats above it may be compared to the air; and the rock oil which ſwims at the top, is ſuppoſed to repreſent the element of fire.

RECREATION LXXXIV.

The magic bottle.

TAKE a ſmall bottle AB, (Pl. XXVIII. Fig. 2.) the neck of which muſt be very narrow*, and have a glaſs veſſel CD, whoſe height exceeds that of the bottle about two inches.

With a ſmall funnel fill the bottle quite full of red wine, and place it in the veſſel CD, which is to be full of water. The wine will preſently come out of the bottle, and riſe, in form of a ſmall column, to the ſurface of the water; and at the ſame time the water entering the bottle, will ſupply the place of the wine; for water being ſpecifically heavier than wine, muſt hold the loweſt place, while the other naturally riſes to the top.

A ſimilar effect will be produced if the bottle be filled with water, and the veſſel with wine. For the bottle

* The mouth of this bottle ſhould not be more than one-ſixth of an inch wide.

being placed in the veſſel, in an inverted poſition, the water will deſcend to the bottom of the veſſel, and the wine will mount into the bottle. The ſame effect may be produced by many other liquors, whoſe ſpecific gravities are conſiderably different.

RECREATION LXXXV.

The compreſſed jet d'eau.

PROVIDE a ſtrong copper veſſel A, (Pl. XXVIII. Fig. 6.) of ſuch figure as you think convenient; in which ſolder a pipe BE, of the ſame metal. Let there be a cock at H, which muſt be made ſo tight that no air can paſs by it. The pipe BE muſt go very near the bottom of the veſſel but not touch it. There muſt be another pipe F, at whoſe extremity G there is a very ſmall hole; this pipe muſt be ſcrewed into the former.

This veſſel being thus diſpoſed, take a good ſyringe, and placing the end of it in the hole, at G, open the cock, and force the air into the veſſel: then turn the cock, and take out the ſyringe. Repeat this operation ſeveral times, till the air in the veſſel be ſtrongly condenſed. Then fill the ſyringe with water, and force it into the veſſel, in the ſame manner as you did the air; and repeat this operation till you can force no more water into the veſſel; then ſhut the cock.

This veſſel will be always ready to perform an extempore jet d'eau: for on turning the cock the ſpring of the compreſſed air will force out the water with great violence, and the jet will continue, though continually decreaſing in force, till the water is all exhauſted, or the air within the veſſel is come to the ſame denſity with that without.

RECREATION LXXXVI.

The marvellous veſſel.

LET there be made a tin veſſel, about ſix inches high, and three inches in diameter, (Plate XXVIII. Fig. 3.) The mouth of this veſſel B, muſt be only one quarter

Fig. 1.

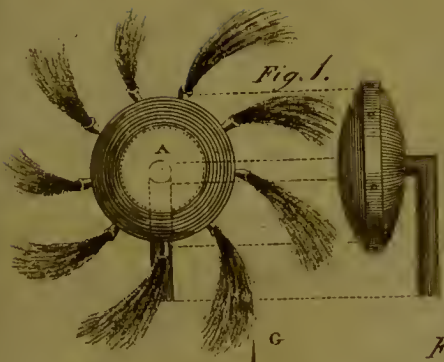


Fig. 2.



Fig. 3.



Fig. 6.



Fig. 7.



Fig. 4.

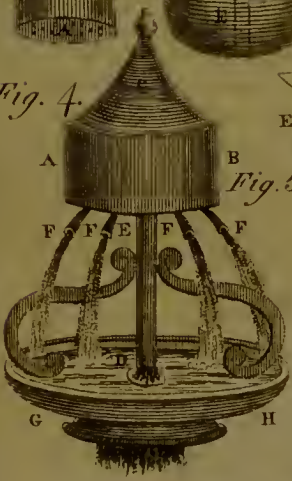
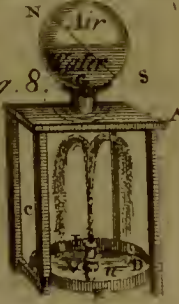


Fig. 5.



Fig. 8.



quarter of an inch wide; and in its bottom at A, make a great number of ſmall holes, about the ſize of a common ſewing needle.

Plunge this veſſel in water, with its mouth open, and when it is full, cork it up, and take it out of the water. So long as the veſſel remains corked, no water whatever will come out, but as ſoon as it is uncorked, the water will iſſue from the ſmall holes at its bottom.

You muſt obſerve, that if the holes at the bottom of the veſſel be more than one ſixth of an inch diameter, or if they be in too great number, the water will run out though the veſſel be corked; for then the preſſure of the air againſt the bottom of the veſſel will not be ſufficient to confine the water.

A Recreation ſimilar to this is made with a glaſs filled with water, over which a piece of paper is placed. The glaſs is then inverted, and the paper drawn dextrouſly away, when the water by the preſſure of the air under it, will remain in the glaſs.

RECREATION LXXXVII.

The circulating fountain.

IN this fountain the boxes CE and DX (Pl. XXVIII. Fig. 5.) being cloſe, you ſee only the baſon AW, with a hole at W, through which the water that ſpouts out at B falls, and runs down, through the pipe WX, into the box DX, from whence it drives out the air, through the aſcending pipe YZ, into the cavity of the box CE, where preſſing upon the water contained in that box, it forces it out through the ſpouting pipe OB, as long as there is any water in CE; ſo that the continuance of the play is while the water in CE ſpouts out and falls down through the pipe WX, into the cavity DX.

The force of the jet is in proportion to the height of the pipe WX, or of the diſtance between the boxes CE and DX. The height of the water, meaſured from the baſon AW to the ſurface of the water in the lower box DX, is always equal to the height, meaſured from the

the top of the jet to the ſurface of the water in the middle cavity CE. Now, ſince the ſurface CE is always falling, and the water DX is always riſing, the height of the jet muſt continually decreaſe, till it is ſhorter by the depth of the cavity CE, which is emptying, added to the depth of the cavity DX, which is always filling; and when the jet is fallen ſo low, it immediately ceaſes. The method of preparing this fountain is as follows. Firſt, pour water in at W, till you have filled the cavity DX, then turn the fountain over, and the water will run from the cavity DX, into the cavity CE, which you will know to be full by the water's running out at B, when it is held down. Set the fountain up again, and pour about a pint of water into the baſon at AW, and as ſoon as it has filled the pipe WX, the fountain will play, and continue as long as there is any water in CE. You may then empty the water left in the baſon into any other veſſel, and invert the fountain: which upon being placed again erect, will begin to play, when the water poured out of the baſon is put into it again. There are fountains of this ſort that have four pipes inſtead of two, and by that mean the water is forced up to twice the height it is in this.

RECREATION LXXXVIII.

The magical caſcade.

PROCURE a tin veſſel AB, (Pl. XXVIII. Fig. 4.) five inches high and five in diameter; with a cover C, cloſed at top. To the bottom of this veſſel let there be ſoldered the pipe DE, of ten inches length and half an inch in diameter: this pipe muſt be open at each end, and the upper end muſt be above the water in the veſſel. To the bottom alſo fix five or ſix ſmall tubes F, about one-eight of an inch diameter. By theſe pipes the water contained in the veſſel is to run ſlowly out

Place this machine on a ſort of tin baſon GH, in the middle of which is a hole of one quarter of an inch diameter. To the tube DE fix ſome pieces that may ſupport the veſſel over the baſon, and obſerve that the end

end D of the tube DE, must be little more than one quarter of an inch from the bason. There must be also another vessel placed under the bason to receive the water that runs from it.

Now, the small pipes discharging more water into the bason than can run out at the hole in its center, the water will rise in the bason, above the lower end of the pipe DE, and prevent the air from getting into the vessel AB, and consequently the water will cease to flow from the small pipes. But the water continuing to flow from the bason, the air will have liberty again to enter the vessel AB, by the tube DE, and the water will again flow from the small pipes. Thus they will alternately stop and flow, as long as any water remains in the vessel AB.

As you will easily know, by observing the rise of the water, when the pipes will cease to flow, and by the fall of it, when they will begin to run again, you may safely predict the change; or you may command them to run or stop, and they will seem to obey your orders.

RECREATION LXXXIX.

The illuminated fountain.

THIS fountain begins to play when certain candles placed round it are lighted, and stops when those candles are extinguished. It is constructed as follows. Provide two cylindrical vessels, AB and CD (Plate XXVIII, Fig. 7.) Connect them by four tubes open at both ends, as HI, &c. so that the air may descend out of the higher into the lower vessel. To these tubes fix candlesticks, and to the hollow cover EF, of the lower vessel, fit a small tube K, reaching almost to the bottom of the vessel. At G let there be an aperture with a screw, whereby water may be poured into CD, which when filled must be closed with the screw.

Now, when candles at H, &c. are lighted, the air in the upper cover and contiguous pipes will be thereby rarified, and the jet from the small tube K will begin

gin to play: as the air becomes more rarified, the force of the jet will increaſe, and it will continue to play till the water in the lower veſſel is exhauſted. It is evident, that as the motion of the jet is cauſed by the heat of the candles if they be extinguiſhed, the fountain muſt preſently ſtop.

RECREATION XC.

The ſolar fountain.

THE motion of the water in this fountain is produced by the heat of the ſun, in the following manner: GNS (Plate XXVIII. Fig. 8.) is a thin hollow globe of copper, of eighteen inches diameter, ſupported by a ſmall inverted baſon, placed on a frame with four legs ABCD, which have between them, at the bottom, a baſon of two feet diameter. Through the leg C paſſes a concealed pipe, which comes from G, the bottom of the inſide of the globe: this pipe goes by HV, and joins the upright pipe *u* I, to make a jet as I. The ſhort pipe *u* I, which goes to the bottom of the baſon, has a valve at *u* under the horizontal pipe, HV, and another valve at V, above that horizontal pipe, under the cock at K. The uſe of this cock is to keep the fountain from playing in the day till you think proper. The north pole N of the globe has a ſcrew that opens a hole whereby water is poured into the globe.

The machine being thus prepared, and the globe half filled with water, let it be ſet it in an open place, when the heat of the ſun, rarifying the air as it heats the copper, the air will preſs ſtrongly againſt the water, which coming down the pipe GCHVI, will lift up the valve at V, and the valve at *u*. The cock being opened, the water will ſpout out at I, and continue to play a long time, if the ſun ſhine.

At night, when the air is condenſed, that which is on the outſide of the veſſel will preſs on the adjutage I, and ſhut the valve V; and at the ſame time preſſing on the water in the baſon D *u* H, which has been played in the day, will puſh it up, through the valve *u*, and

x, and pipe u H G, into the globe, ſo as to fill it again to the ſame height as at firſt. When the ſun ſhines again on the globe, the fountain will play again, &c. A ſmall jet will play ſix or eight hours.

If the globe be ſet to the latitude of the place, and rectified before it be fixed, with the hour lines or meridians drawn upon it, the hours marked, and the countries painted, as on the common globe, it will form a good dial; the ſun then ſhining upon the ſame places in this globe, as it does on the earth itſelf. This fountain was invented by Dr Deſaguliers.

RECREATION XCI.

The cup of Tantalus.

IN this cup is placed a ſyphon, the ſhorteſt leg of which is near the bottom of the cup, and the longeſt is concealed in the handle. If water be poured into this cup it will not run out till it come above the top of the bended part of the ſyphon, and then, by the preſſure of the air, it will be forced up the ſhort leg, and run out by that in the handle, till the water in the cup be lower than the ſhort leg of the ſyphon, which may be placed very near the bottom of the veſſel. If the cup be filled juſt to the top of the ſyphon, and an apple or orange thrown in, it will, by raiſing the water, have the ſame effect as pouring in more.

This is called the cup of Tantalus, from the reſemblance of an experiment ſometimes made with an image placed upright in the cup, (Plate XXIX. Fig. 1.) to the fable of Tantalus. For a ſyphon being placed in the body of the image, one end of which beginning at the bottom of one foot at A, riſes to the upper part of his breaſt, from thence deſcends through the other leg, on which he ſtands, and from thence through the bottom of the cup, into the lower part at B. As ſoon as the water riſes to the chin of the image, above S, it will begin to run out, in the ſame manner as from the cup above-mentioned.

RECRE-

RECREATION XCII.

The sea gage.

THIS instrument is constructed as follows. AB (Pl. XXIX. Fig. 2.) is the gage bottle, in which is cemented the gage tube F*f*, in the brass cap at G. The upper end of the tube F is hermetically sealed, and the lower, open end *f*, is immersed in mercury, marked C, on which swims a small surface of treacle. On the top of the bottle is screwed a pipe of brass, GH, pierced with several holes, to admit the water into the bottle AB. K is a weight hanging by its shank L, in a socket N, with a notch on one side at *m*, in which is fixed the catch *l*, of the spring *s*, which passing through the hole L, in the shank of the weight K, prevents its falling out, when once hung on. On the top, in the upper part of the brass tube, at H, is fixed a large empty ball, or full blown bladder I, which must be of such a size that the weight K may be able to sink the whole under water.

This instrument is used in the following manner. The weight K is hung on, and the gage being let fall into deep water, sinks to the bottom: the socket N is something longer than the shank L, and therefore, after the weight K comes to the bottom, the gage will continue to descend, till the lower part of the socket strike against the weight; this gives liberty to the catch to fly off the hole L, and let go the weight K. When this is done, the ball or bladder I, instantly buoys up the gage to the top of the water.

While the gage is sinking, the water having free access to the treacle and mercury in the bottle, will, by its pressure, force it up in the tube F*f*; and the height to which it has been forced by the greatest pressure, which is that at the bottom, will be shewn by the mark in the tube which the treacle leaves behind it; and which is here its only use. This shows into what space the whole air in the tube F*f* is compressed, and consequently

Fig. 1.

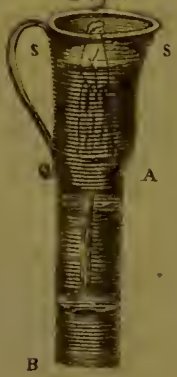


Fig. 3.

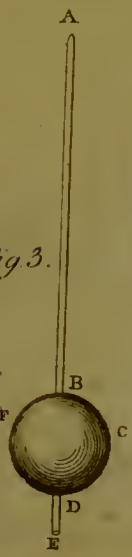


Fig. 2.

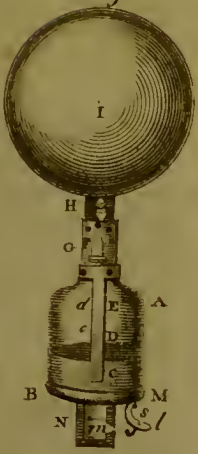


Fig. 4.

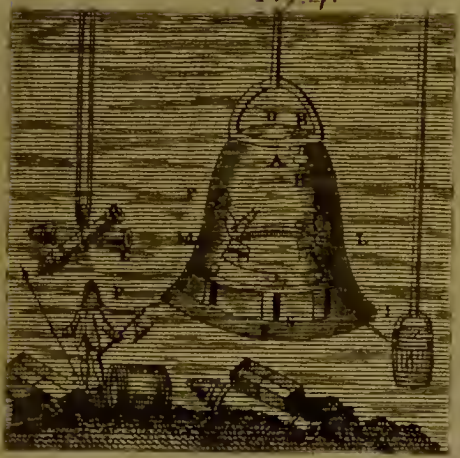
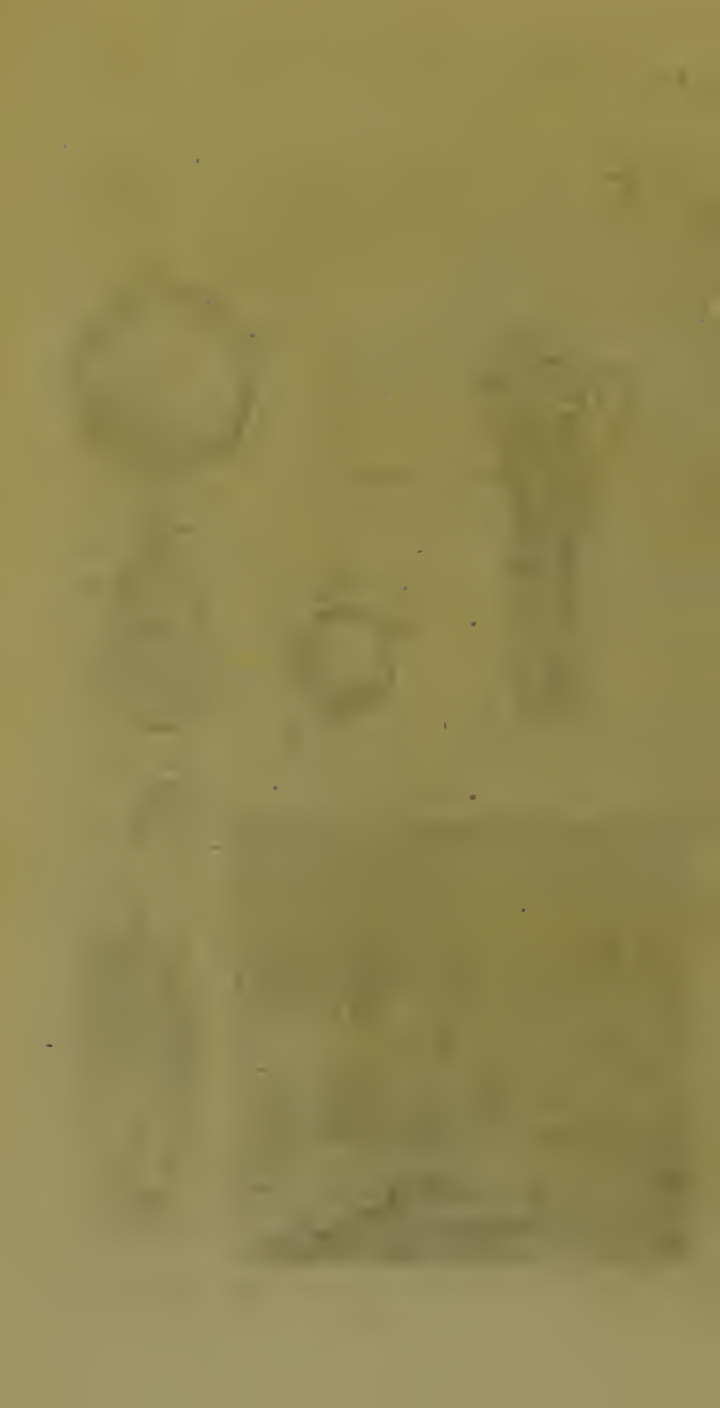




Fig. 5.





quently the depth of water, which by its weight produced that compreſſion.

If the gage tube F*f* be of glaſs, a ſcale may be drawn on it with the point of a diamond, which will ſhew by inſpection at what height the water ſtands above the bottom. But the length of ten inches is not ſufficient to fathom depths at ſea; for when all the air in ſuch a length of the tube is compreſſed into half an inch the depth of water is not more than 634 feet, which is not half a quarter of a mile.

If to remedy this, we uſe a tube 50 inches long, which for ſtrength, may be a muſket barrel, and if the air be compreſſed into the hundredth part of half an inch, even then the depth will be but 3300 feet, that is 660 feet more than half a mile. But it is reaſonable to ſuppoſe the cavities of the ſea bear a near proportion to the mountainous parts of the land, ſome of which are more than three miles high. Therefore to inveſtigate the greateſt depths of the ſea, the following improvement was made to the foregoing apparatus.

Let BCDF, Fig. 3, be a hollow metal globe, on the top of which is fixed the long tube AB, whoſe capacity is one-ninth part of the globe. At the lower part D, it has a ſhort tube DE, which is to ſtand in the mercury and treacle. The air contained in this compound gage-tube is compreſſed by the water, as before; but the degree of compreſſion, or height to which the treacle has been forced, cannot here be ſeen through the tube: therefore, to anſwer the ſame end, a ſlender rod of metal or wood, with a knob at the top of the tube AB, will receive the mark of the treacle, and ſhow it when taken out.

If the tube be 50 inches long, and of ſuch a bore that every inch in the length be equal to a cubic inch of air, and the contents of the globe and tube together be 500 cubic inches; then if the air be compreſſed within a hundredth part of the whole, it is evident that the treacle will not approach the top of the tube nearer than five inches, which will anſwer to the depth of

3300 feet of water, as above. Twice that depth will compreſs the air into half that ſpace, nearly, that is, two inches and a half, which correſponds to 6600 feet, or a mile and a quarter. Laſtly, half that ſpace, or an inch and a quarter, will anſwer to double the laſt depth, that is, 13,200 feet, or two miles and a half; which is, probably, very near the greateſt depth of the ſea. This ſea-gage was invented by the Drs Hales and Defaguliers.

RECREATION XCIII.

The diving-bell.

THERE have been many machines invented to explore the hidden chambers of the deep; as may be eaſily imagined: for when curioſity is joined by avarice they ſtrongly excite the inventive faculty. Of all thoſe machines the moſt complete is that invented by Dr Halley, who does not appear, however, to have been excited by any other motive than curioſity; nor is it wonderful: for to a man of his exalted faculties one motive only is equal to many, when acting conjointly on a vulgar mind.

This machine was in the form of a bell (Pl. XXIX. Fig. 4.) It was three feet wide at top, five at bottom, and eight feet high, and contained about forty-three cubic feet, or near eight hogſheads.

The machine was coated with lead, and ſo heavy that it would ſink empty. The weight was diſtributed about the bottom IK, ſo that it would go down in a perpendicular direction only. In the top was fixed a ſtrong clear glaſs D, to let in the light from above. There was likewiſe a cock at B, to let out the hot, foul air. Below was fixed a circular ſeat LM, for the divers to ſit on; and laſtly, from the bottom hung, by three ropes, a ſtage for them to ſtand on, while they were performing their operations. This machine was ſuſpended from the maſt of a ſhip by a ſprit, which was ſufficiently ſecured to the maſt-head by ſtays, and

was

was directed by braces to carry it over board, clear of the ſide of the ſhip, and to bring it in again.

To ſupply the bell with air under water were made two barrels, ſuch as C, of about 63 gallons each, and caſed with lead, ſo that they would ſink empty; each of them had a hole in the lower part, to let in the water, as the air in them was condenſed in their deſcent, and to let it out again when they were drawn up from below.

To a hole in the top of the barrel was fixed a leathern pipe, well prepared with bees-wax and oil; this pipe was long enough to fall below the hole at the bottom, and kept down by a weight hanging to it, ſo that the air in the upper part, driven there by the encroachment of the water in the deſcent, could not eſcape, unleſs the lower end of the pipe was lifted up.

Theſe air barrels were fitted with tackle adapted to make them riſe and fall alternately, like two buckets in a well. In their deſcent they were directed by lines, faſtened at the under edge of the bell, to the man ſtanding on the ſtage to receive them; who by taking up the ends of the pipes above the ſurface of the water in the bell, gave liberty to the water in the barrels to force all the air in the upper parts into the bell, while it entered below and filled the barrels: and as ſoon as one was diſcharged, at a ſignal given, it was drawn up, and the other deſcended to be ready for uſe.

As the cold air ruſhed into the bell from the barrels below, it expelled the hot air through the cock B, at the top of the bell, which was then opened for that purpoſe. By this method air was communicated ſo quick, and in ſuch plenty, that the Doctor tells us, he himſelf was one of five who was at the bottom in nine or ten fathom water, for more than an hour and a half together, without any ſort of ill conſequence: and for any thing that appeared to the contrary, he might have continued there as long as he pleaſed.

In going down, it is neceſſary the deſcent ſhould be at firſt very gentle, that the denſe air may be inſpired,

to keep up by its ſpring, a balance to the preſſure of the air in the bell. At each twelve feet of deſcent the bell was ſtopped, and the water that entered was driven out, by letting in three or four barrels of freſh air. By this means, and by taking off the ſtage, the bottom of the ſea could be ſo far made dry, within the circuit of the bell, as not to be over ſhoes thereon.

By the glaſs on the top of the bell ſo much light entered, when the ſun ſhined, and the ſea was clear and even, that Dr Halley could ſee diſtinctly to read and write. By the return of the air barrels he ſent up orders, wrote with an iron pen on ſmall pieces of lead, directing where the bell was to be moved. But in dark weather when the ſea was rough, the bell would be as dark as night: but then the Doctor obſerved, he could keep a candle burning in the bell as long as he pleaſed; for it is found by experiment, that a candle conſumes as much air in a minute as a man, that is, about one gallon.

The only inconvenience attending this bell was, that upon the firſt going down, they felt a ſmall pain in their ears, as if the end of a quill was forcibly thruſt into them. This pain preſently ceaſed, but on deſcending lower returned again, and again ceaſed; and ſo alternately, till the machine got to the bottom, then the air remained of the ſame denſity. This inconvenience is ſuppoſed to be occaſioned by the condenſed air ſhutting up a valve, leading from ſome cavity in the ear, full of common air; but as the condenſed air continues to preſs harder, it forces the valve to give way, and fills every cavity. One of the divers, thinking to prevent this preſſure, ſtopped his ears with a pledget of paper; which, as the bell deſcended, was forced ſo far into his ears, that it was with great difficulty the ſurgeon could extract it.

This bell was ſo improved by the inventor, that he could detach one of his divers to the diſtance of a hundred

hundred yards from it. For this purpoſe he contrived a cap or head-piece, ſomething like an inverted hand-baſket, as F, with a glaſs in the fore part, for the diver to ſee his way.

This cap was of lead, and made to ſit quite cloſe about his ſhoulders: in the top of it was fixed a flexible pipe, communicating with the bell, and by turning a ſtop-cock near his head-piece, he received air whenever he pleaſed. There was alſo another cock at the end of the pipe in the bell, to prevent any accident happening from the perſon without. This perſon was well cloathed with thick flannels, which were warmed upon him before he left the bell, and would not ſuffer the cold water to penetrate; he was alſo furniſhed with a girdle of large leaden weights, and clogs of lead for the feet, which, with the weight of the leaden cap, kept him firm on the ground. His cap contained air enough to ſerve him a minute or two; then by raiſing himſelf above the bell, and turning the cock F, he could repleniſh it with freſh air. The pipe he coiled round his arm, which ſerved him as a clue to find his way back to the bell. ...

Since the invention of the above diving machine, there has been one contrived by M. Triewald, F. R. S. and military architect to the King of Sweden, which, for a ſingle perſon, is in ſome reſpects more eligible, and is conſtructed as follows. AB, (Plate XXIX. Fig. 5.) is the bell, which is ſunk by lead weights DD, hung to its bottom. This bell is of copper, and tinned all over on the inſide, which is illuminated by three ſtrong convex lenſes G, G, G, with copper lids, H, H, H, to defend them. The iron ring or plate E, ſerves the diver to ſtand on when he is at work, and is ſuſpended at ſuch a diſtance from the bottom of the bell, by the chains F, F, F, that when the diver ſtands upright, his head is juſt above the water in the bell, where the air is much better than higher up, becauſe it is colder, and conſequently more fit for reſpiration. But as the diver muſt be ſometimes entire-

ly within the bell, and his head of courſe in the upper part, the inventor contrived, that even there, when he has breathed the hot air, as long as he well can, he may, by means of a ſpiral copper tube C placed cloſe to the inſide of the bell, draw the cooler and freſher air from the lowermoſt parts; for which purpoſe a flexible leather tube, about two feet long, is fixed by one end to the upper part of the copper tube; and to the other end is fixed an ivory mouth-piece, by which the diver reſpires the air from below.

PYROTECHNICS.

DEFINITIONS.

1. PYROTECHNICS, is that branch of phyſiology which explains the nature of fire, and the manner of employing it in offices of uſe or pleaſure.

2. Fire is ſaid to be of ſix degrees.

3. The firſt degree of fire is that meaſured by Farenheit's thermometer between its firſt and 80th degree; and is the limit neceſſary to vegetation.

4. The ſecond degree of fire, is that contained between the 40th and 94th degrees of the ſame thermometer: and is that neceſſary to animal life.

5. The third degree of heat extends from the 94th to the 212th degree of that thermometer; the laſt of which is commonly that of boiling water.

6. The fourth degree of heat is extended to the 600 degree of the ſame thermometer; which is very near the boiling point of mercury: within this degree lead and tin melt*.

7. The fifth degree of heat is that in which all metals and fixed ſalts melt, and moſt other bodies vitrify or become volatile. This is the extreme heat of a chemical furnace.

8. The ſixth degree of heat is that of the focus of a large lens or mirror, which no ſubſtance can ſuſtain unaltered.

9. Heat is divided into abſolute and relative; abſolute heat is that which exiſts in any ſubſtance: and relative or comparative heat is that which is perceived by an animal body.

APHORISMS.

* Theſe diviſions of heat by the thermometer, were firſt fixed by the illuſtrious Boerhaave.

APHORISMS.

1. Abſolute heat proceeds from an inteſtine motion in the parts of any body*.

2. Relative heat ariſes from the degree of inteſtine motion in any ſubſtance being greater than that of the animal body to which it is applied.

3. There is the ſame affinity between abſolute and relative heat, as between motion and velocity: abſolute heat being the whole motion of all the parts of the heated body, and relative heat only the comparative velocity of the parts†.

4. When the motion of the parts of an inflammable body is increaſed to a certain degree, it will throw off a quantity of particles, in form of ſmoke. If the velocity be further increaſed, thoſe particles will become ſparks of fire: and if the velocity be ſtill further increaſed, thoſe particles will make a body of fire, in the form of a flame.

5. The effect of fire in burning proceeds from the velocity of its particles, which ſo far increaſe the velocity of thoſe of the body to which it is applied, as to ſeparate them from the body, and drive them beyond the ſphere of its attraction. By which mean the body is diſſolved, ſuch of its particles as are volatile fly off in ſmoke or flame, and the reſt remain in the form of a calx or aſhes.

6. The force or burning power of the particles of fire when condenſed, as in the focus of a lens or mirror,

* This is the doctrine of fire maintained by the Engliſh philoſophers: thoſe of other nations aſſert, in general, that fire is an element, like air and water, that is contained in all bodies, and obtainable from them by attrition or pulſation.

† This is exemplified by placing equal quantities of mercury and water over a fand heat, where the fire being uniformly communicated to each of them, they will acquire, in the ſame time, the ſame degree of abſolute heat: but the relative heat, or that that is ſenſible to an animal body, will be near fourteen times greater in the water than the mercury; for the water having fourteen times leſs matter, will have acquired a velocity, in proportion as much greater.

tor, are increaſed in proportion to the area of the glaſs, directly, and the ſquare of the focal diſtance, inverſly*.

7. The forcing of heat increaſes in proportion to the ſquares of the diſtances, inverſly; that is at the diſtance of one foot the fire is four times as ſtrong as at two feet, and nine times as ſtrong as at three feet; and ſo in proportion.

8. The dimenſions of bodies in general, are increaſed by heat†.

9. Fire pervades, and is found in all bodies.

10. The immediate inflammable matter of every body is oil, or an unctuous ſubſtance.

11 No ſubſtance will continue to burn without the admiſſion of freſh air.

12. Fire acts in all directions from the ignited body, as from a center.

RECREATION XCIV.

The inflammable phoſphorus‡.

TAKE the meal or flour of any vegetable, put it into an iron pan over a moderate fire, and keep it ſtirring with an iron ſpatula, till it be converted into a black powder: to one part of this add four parts of crude alum. Make the whole into a fine powder, which, being put into an iron pan over the fire, is to be

* For example: ſuppoſe the area of one glaſs to be twelve ſquare inches, and its focal diſtance nine inches; and the area of another to be ten inches, and its focal diſtance five inches. Then the burning power of the former will be to the latter as 12 multiplied by 25, is to 10 multiplied by 81; that is, as 300 to 810, or as 30 to 81.

† Dr Halley found that water has no perceptible expanſion when gently heated, but when boiled, expands one twenty-ſixth part. Mercury with a very gentle heat expands one ſeventy-fourth part, and ſpirit of wine, with a heat much leſs than that of boiling water, expands one-twelfth. M. Muſchenbroek found the expanſions of the following metals in the ſame heat, to be in proportions here ſet down. Silver 78; iron 80, ſteel 85; copper 89; braſs 110; tin 153; lead 155.

‡ For a more eaſy method of preparing a lucid phoſphorus, ſee p. 41.

be kept conſtantly ſtirring with a ſpatula till almoſt ignited, to prevent its cohering in lumps, as it is apt to do upon the melting of the alum, in which caſe it muſt be broke again, ſtirred about, and accurately mixed with the flour, till it emit no more fumes, and the whole appear a fine, dry, black, fixed powder.

Put this powder in a clear, dry phial, with a narrow neck, filling to about one-third from the top. Then ſtop the mouth of the phial with looſe paper, ſo as to let the air paſs freely through it, and leave room for fumes to come through the neck. Place the phial in a crucible, encompaſſed on all ſides with ſand, but ſo that it may not touch any part either of the bottom or ſides of the crucible, but a conſiderable ſpace be every where left between them. The phial muſt be covered up with ſand, ſo as only to leave a part of it bare, through which you may perceive whether the matter be ignited. In this ſtate the crucible is to be ſurrounded with coals kindled ſlowly, till it be well heated on all ſides, when the fire is to be raiſed, till the crucible, ſand, gravel, glaſs and matter in it, be red hot; in which ſtate they are to be kept for an hour; after this the fire being ſtill kept up, the orifice of the phial is to be well cloſed with wax, to prevent any air from entering. Thus the whole being left to cool undiſturbed, you will at laſt find in the phial a black duſty coal, formed of the flour and alum.

A ſmall quantity of the matter contained in this phial being ſhook out, into the cold air, immediately takes fire and burns; but having once felt the air, loſes all power of kindling thereby. This manner of producing fire appears the moſt extraordinary of all that have hitherto been diſcovered, ſince the matter thus prepared will preſerve its virtue three months, provided the air be kept from it: but if the ſmalleſt quantity of moiſture, even of that little which is lodged in the air, come to touch this powder, the experiment will not ſucceed.

RECREATION XCV.

The liquid phoſphorus.

TAKE a piece of Engliſh phoſphorus, about the ſize of a pea, and cutting it very ſmall, put it into half a glaſs of quite clear water. Boil it in a little earthen veſſel over a moderate fire. Have a phial with a narrow neck and a glaſs ſtopper; take out the ſtopper and plunge the phial in boiling water: then take it out, and pouring out the water, put the boiling mixture immediately into it: inſtantly ſtop the phial, and cover it with a cement, that the air may not in any degree enter it.

This mixture will ſhine in the dark for ſeveral months, though the phial be not touched: if it be ſhook, eſpecially in warm, dry weather, very ſtrong lightnings will dart from the middle of the water.

Some pleaſing amuſements may be produced by putting this phoſphorus in a long or broad phial, and paſting a paper over it, in which letters or figures are cut.

RECREATION XCVI.

The fulminating gold.

PLACE a ſmall mattraſs, on a ſand heat, and put one part of filings of pure gold and three parts of aqua regia. When the liquor has entirely diſſolved the gold, put the mixture in a phial, and add five or ſix times as much common water.

Then take ſpirit of ſal ammoniac, or oil of tartar, and pour it, drop by drop, on the diſſolution till the ebullition ceaſe. Let this mixture reſt, till the gold be entirely precipitated to the bottom of the phial. Pour the water that ſwims at the top gently off, and after waſhing this gold duſt ſeveral times in common water, dry it by a very moderate heat, by putting it on a paper that will abſorb all its moiſture.

If a grain of this powder be put in a copper ſpoon, over the flame of a candle, as ſoon as it is well heated,

ed, it will go off with a report like that of a piſtol. If the ſpoon be not ſufficiently ſtrong, the matter will run through it, and make an exploſion underneath, with great violence.

RECREATION XCVII.

The burning fountain.

MAKE a veſſel of tin or copper, as ABCD, (Plate XXX. Fig. 11.) or of what other form you pleaſe. Let there be an eolipile E, of the ſame metal, and of the ſize and figure of a pear, and let its neck paſs through the top of the veſſel where it ſhould not be of more than one quarter of an inch diameter; to this neck join the pipe F, whoſe bore at the extremity ſhould be extremely ſmall, and there muſt be a ſmall cock at G, that goes acroſs it. Pour ſome ſpirit of wine into the eolipile, and having filled the veſſel with boiling water, cover it over.

The heat of the boiling water rariſying the air contained in the eolipile, it will preſs on the ſurface of the ſpirit of wine, and force it through the ſmall hole at the end of the pipe. Therefore if the flame of a candle be placed cloſe to the orifice of the pipe, the ſpirit will take fire, and it will form a flaming fountain, that will have a pleaſing effect; and if the orifice of the pipe be quite ſmall will continue for ſome time.

This piece may be executed on a larger plan, and many of the jets deſcribed under the article of Hydraulics, may be annexed to the eolipile; taking care always that the orifice by which the ſpirit is to paſs be extremely ſmall. If filings of iron be ſifted over theſe jets, through a very fine ſieve, they will take fire, and imitate exactly the appearance of fireworks.

RECREATION XCVIII.

Prince Rupert's drop.

TAKE up a ſmall quantity of the melted matter of glaſs, with a tube, and let a drop fall into a pail of water,

Fig. 1.



Fig. 2.



Fig. 5.



Fig. 6.



Fig. 8.



Fig. 9.

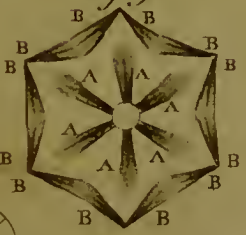


Fig. 3.



Fig. 7.



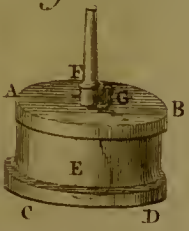
Fig. 10.



Fig. 4.



Fig. 11.



water, by which it will retain its form, and appear ſolid throughout: except that it contain a few air bubbles. This drop will have a ſmall tail, which being broke the whole ſubſtance of the drop will burſt, with great violence, into a fine powder; and give a little pain, but do no hurt to the hand that breaks it.

It is remarkable, that the bulb or body will bear the ſtroke of a hammer without breaking, but if the tail be broke, the abovementioned effect is produced. If the drop be cooled in the air, it will not produce the effect; and if it be ground away on a ſtone, nothing extraordinary appears. But if it be put into the receiver of an air pump, and there broke, the effect will be ſo violent as to produce light.

This phenomenon is ſuppoſed to proceed from the particles of the glaſs being in a ſtate of repulſion, while melted, but by being dropped into cold water, the external particles are condenſed, and hold the internal, which are ſtill in a ſtate of repulſion, as in a caſe; but when an opening is made in that caſe, by breaking off the tail, the confined particles ruſh forth, and burſt the drop with the greateſt violence.

RECREATION XCIX.

The revivified roſe.

TAKE a roſe that is quite faded, and throwing ſome common ſulphur on a chafing-diſh of hot coals, hold the roſe over the fumes, and it will become quite white. Then dip it in a baſon of water, and giving it to any one, tell him to put it in his box or drawer, and after locking it, to give you the key. When you return him the key five or ſix hours after, and he unlocks his drawer, inſtead of the white roſe he puts in it, he will find one that is perfectly red.

RECREATION C.

Writing on glaſs by the rays of the ſun.

DISSOLVE chalk in aqua fortis, to the conſiſtence of milk, and add to that a ſtrong diſſolution of ſilver.

Keep this liquor in a glaſs decanter well ſtopped. Then cut out from a paper the letters you would have appear, and paſte the paper on the decanter, which you are to place in the ſun, in ſuch a manner that its rays may paſs through the ſpaces cut out of the paper, and fall on the ſurface of the liquor. The part of the glaſs through which the rays paſs will turn black, and that under the paper will remain white. You muſt obſerve not to move the bottle during the time of the operation.

RECREATION CI.

The magic picture.

TAKE two pieces of glaſs about three inches long and four wide: they muſt be quite level, and exactly of the ſame ſize. Place them one over the other, and let there be about one twentieth part of an inch between them, which you may effect by paſting papers on their four corners. Join theſe two glaſſes together by a luting compoſed of lime ſlacked by lying in the air and reduced to very fine powder, mixed with the white of an egg. Cover all the borders of theſe glaſſes with parchment or bladder, except a ſmall opening left on one ſide, in order to introduce the following compoſition.

Diſſolve by a ſlow fire ſix ounces of fine hogs-lard, and put to it half an ounce of white wax, and if you find it neceſſary to render it more ſenſible to the heat, add an ounce, or more of the cleareſt linſeed oil. This, when liquid, is to be poured between the glaſſes by the ſpace left in their ſides, and which you are then to ſtop cloſe up. Wipe the glaſſes clean and hold them before the fire, to ſee that the compoſition will not run out at any part. Then paſte a picture, painted on any thin ſubſtance, or a coloured print, with its face to one of the glaſſes, and fix the whole in a frame.

The mixture between the glaſſes, while it is cold, will quite conceal the picture, but becoming perfectly tranſparent by heat, the painting will appear as if there was only a ſingle glaſs before it. As the compoſition cools,

cools, the picture will gradually disappear, and at last be quite invisible.

RECREATION CII.

The luminous oracle.

PROCURE a tin box ABCD, (Pl. XXXII. Fig. 1.) about eight inches high, four wide, and two deep, and let it be fixed on the wooden stand E. On two of the insides let there be a groove FG, and in the front an opening I, three inches wide and one high.

At the back of the box let there be a little tin door, that opens outward, by which two wax candles M, may be put in. Let the top of the box have a cover N, of the same metal, in which there are several holes, and which may be taken off at pleasure.

Provide a double glass OP, Fig. 2, constructed in the same manner as that in the last Recreation. On one of its sides you are to paste a black paper, the length of which is to be divided into three parts, and the breadth into fifteen: in every two of these fifteen divisions you cut out letters, which will make in the whole three answers, to three questions that may be proposed. On the other side of the glass paste a very thin paper, and to the top fasten a small cord, by which they may be made to rise or descend in the groove FG.

Then take a slip of pasteboard RS, Fig. 3, one inch and a half wide and three inches long, which is to be divided into fifteen equal parts, similar to those of the paper OP, and cut out spaces, as in the figure, so that this paper, sliding horizontally before OP, will either cover or conceal the letters cut in that.

This pasteboard is to slide between two brass wires, and is to be fastened to one side of the box, by a string that communicates with a small brass spring, and to the other side, by a string fastened to the box by a small piece of wax, so situate that the string may be easily set at liberty by the heat of the candles placed in the box.

Take a parcel of cards, and write on them different queſtions, three of which are to correſpond with the anſwers on the glaſs. Shuffle theſe cards, and let a perſon draw any one of the three queſtions. Then by raiſing the glaſs you bring the anſwer againſt the hole in the front of the box. You next place the candles in the box, the heat of which will melt the wax that holds the paper RS, which being then drawn by the ſpring the anſwer will be viſible, and in proportion as the compoſition between the glaſſes becomes diluted, by the increaſe of the heat, the letters will become more ſtrongly illuminated.

The letters cut in the paper may be made to anſwer ſeveral different queſtions, as has been explained in other Recreations: and the whole parcel of cards may conſiſt of queſtions that may be anſwered by one or other of the three diviſions in the paper.

RECREATION CIII.

To produce the appearance of a flower from its aſhes.

MAKE a tin box ABCD, (Plate XXXII. Fig. 4) with a cover M, that takes off. Let this box be ſupported by the pedeſtal FGHI, of the ſame metal, and on which there is a little door L. In the front of this box is to be a glaſs, O.

In a groove, at a ſmall diſtance from O, place a double glaſs of the ſame ſort with that in the laſt Recreation. Between the front and back glaſſes place a ſmall upright tin tube, ſupported by the croſs-piece R. Let there be alſo a ſmall chafing-diſh placed in the pedeſtal FGHI. The box is to be open behind. You privately place a flower in the tin tube R*; and preſenting one that reſembles it to any perſon†, deſire him to burn it on the coals in the chafing-diſh.

You

* This flower muſt not be placed ſo near the front glaſs, as to make it in the leaſt degree viſible.

† You may preſent ſeveral flowers, and let the perſon chooſe any one of them. In this caſe while he is burning the flower, you

You then ſtrew ſome powder over the coals, which may be ſuppoſed to aid the aſhes in producing the flower; and then put the chafing-diſh in the pedeſtal, under the box. As the heat by degrees melts the compoſition between the glaſſes, the flower will gradually appear, but when the chafing-diſh is taken away, and the power of the aſhes is ſuppoſed to be removed, the flower ſoon diſappears.

RECREATION CIV.

To produce fire by the mixture of two cold liquors.

TAKE half a pound of pure dry nitre, reduced to powder, put it in a retort that is quite dry, add to it an eqnal quantity of oil of vitriol highly rectified, and diſtilling the mixture in a moderate ſand heat, it will yield a liquor in form of a yellowiſh fume, which being caught in a clean dry receiver, is the *Spiritus nitri Glauberianus*. Now if to a dram of diſtilled oil of cloves, ſaſſafras, turpentine, or caraways, contained in a glaſs veſſel, there be added an equal quantity or half as much more, of the above ſpirit, though both the bodies are perfectly cold before the mixture, a violent flame will inſtantly ariſe and deſtroy them, leaving only a little reſinous matter at the bottom.

RECREATION CV.

Artificial lightning.

PROVIDE a tin tube that is much larger on one ſide then the other, and in which there are ſeveral holes. Fill this tube with roſin in powder, and when it is ſhook over the flame of a torch, it will produce a ſudden coruſcation, that ſtrongly repreſents a flaſh of lightning. You are to obſerve that it is not the flame itſelf that is to be ſeen, but its reflection, as is practiſed

 at

you fetch the box from another apartment, and at the ſame time put in a correſponding flower, which will make the experiment ſtill more ſurpriſing.

at the theatres, and as happens, for the moſt part, in nature*.

RECREATION CVI.

Artificial thunder.

TAKE a ſtrong bottle that holds about a quarter of a pint, in which put one ounce of concentred ſpirit of vitriol, and adding to that two drachms of the filings of iron, ſtop the bottle cloſe. After a ſhort time ſhake the bottle, and taking out the cork, put a lighted candle near the mouth of it, which ſhould be a little inclined, and there will preſently ariſe an inflammation, attended with a loud noiſe.

If you are apprehenſive of any miſchievous effects from the burſting of the bottle, you may ſurround it with a ſtrong cloth: or you may put it on the ground and light the vapour by a bougie fixed to the end of a long ſtick.

Another way of imitating thunder is by mixing three parts of ſaltpetre, two parts of ſalt of tartar, and two parts of ſulphur, and putting the quantity of a ſmall nut in an iron ladle or ſhovel, place it over a coal fire. The exploſion of this mixture will much reſemble a moderate clap of thunder.

If you would produce a more violent exploſion, put an ounce or two of this mixture in the ſhovel, but then you muſt have a chafing-diſh of hot coals, and placing it out of the houſe, ſtand at a conſiderable diſtance from it, and not go near it, till the matter be completely exploded, or what is better, till the fire be out. Experiments of this nature ſhould, in general, be conducted with great caution, for an amuſement of this kind would be dearly bought with a wound in the face, or the loſs of ſight.

RECRE-

* It is after this manner that the flambeaux of the furies on the ſtage are conſtructed, except that at the end of each of them there is a match, dipped in ſpirit of wine, by means of which it is only neceſſary to ſhake them, and they will produce a ſudden and very conſiderable flame.

RECREATION CVII.

The predicted earthquake and volcano.

GRIND freſh iron filings, free from ruſt, with an equal quantity of pure ſulphur, for a long time, till the whole be formed into a fine powder. This mixture kept in a dry air will continue cold for any time, but if it be wrought up with only as much fair water as will form it into a ſtiff paſte, the maſs will ſoon grow warm, ſwell, heave, emit a thick ſmoke, and at laſt a ſulphureous fire and flame. Therefore take about fifty pounds of the above powder, and, burying it privately about a foot deep under the earth, you, may ſafely predict that in about eight hours time the ground will begin to heave and ſwell, that it will ſend forth hot ſulphureous ſteams, and at laſt, burſting into live flames, will form a true volcano.

The pretended miracles of Mahomet and Haly, were, as Boerhaave obſerves on a ſimilar inſtance, mere trifles to this. If any leader of a ſect, a very few centuries paſt, had been in poſſeſſion of this ſecret, and had performed this miracle in confirmation of his doctrine, the man who had dared to diſbelive it would have been regarded as a very hardened infidel indeed!

We ſhall here add the deſcription of a new method of imitating artificial fire-works, which appears to be the invention of the ingenious M. Guyot.

To perform theſe recreations to the greateſt advantage, there are three circumſtances to be carfully obſerved: the firſt is, the different colours of the fire: the ſecond, is the manner of cutting out the ſeveral figures, and the third, the direction of the motion of each piece, whether it be ſwift or ſlow, ſtrait or circular.

Artificial fireworks may be reduced to four principal colours. The firſt is that of jets of fire, which is of a clear white: the ſecond is that of ſuch jets as are of a yellow or gold colour: the third is that of ſerpents or rockets,

rockets, which is very bright, and of a light blue caſt: * and the fourth is that of a colour inclining to red, and is commonly uſed in caſcades of fire.

The vivacity of fire being imitated, by the rays of light that fall upon tranſparent paper†, as we ſhall ſhow hereafter, the paper is to be ſtained with different colours. For the firſt ſort of fire it is left of its natural colour: for the ſecond an infuſion of ſaffron may be uſed, made more or leſs ſtrong: for the third a light tincture of Pruſſian blue: and for the fourth, a ſmall quantity of carmine may be put in the ſaffron water juſt mentioned.

If among theſe fireworks you would have ſome parts that are tranſparent, and through which other parts are to be ſeen, you muſt uſe for the tranſparent parts a paper that is thicker than the other, that the latter may appear with a due degree of ſuperior luſtre: for in theſe exhibitions it is from a juſt mixture of light and ſhade that the moſt pleaſing effects are produced.

RECREATION CVIII.

To imitate a jet de feu, column, globe, or pyramid of fire.

TAKE a paper that is blacked on both ſides‡, and of a proper ſize for the figure you intend to exhibit, for example, that of Fig. 1 or 2, Plate XXX. In this paper cut out with a pen-knife ſeveral ſpaces B, beginning from the point A; and with a piercer make a great number of holes, rather long than round, and at no regular diſtance from each other: obſerving, how-

* There is another ſort of fire of a ſtronger blue, of which cyphers and emblems are formed, and which is placed on the centers of ſuns.

† The paper ſhould be quite thin, and after it is coloured, may be made more tranſparent by being dipped in, or rubbed over with clear oil.

‡ Inſtead of black, the paper may be coloured on each ſide with a deep blue, which will be ſtill better for ſuch as are to be ſeen through tranſparent papers.

however, that they muſt form right lines from the point A, as is clearly expreſſed in the figures, the parts engraved being thoſe that are to be cut out.

To repreſent revolving pyramids and globes, ſuch as Fig. 3 and 4, the paper muſt be cut through with a pen-knife, and the ſpace cut out between each ſpiral ſhould be three or four times as wide as the ſpirals themſelves. You muſt obſerve to cut them in the ſame form repreſented in the figures, that the pyramid or globe may appear to turn on its axis. The columns that are repreſented in pieces of architecture, or in jets of fire, muſt be cut in the ſame manner, if they are to be repreſented as turning on their axes.

In like manner may be exhibited a great variety of ornaments, cyphers, and medallions, which, when properly coloured, cannot fail of producing a moſt pleaſing effect*.

When theſe pieces are drawn on a large ſcale, the architecture or ornaments may be ſhaded; and to repreſent different ſhades, pieces of coloured paper muſt be paſted over each other, which will produce an effect that would not be expected from tranſparent paintings. Five or ſix pieces of paper paſted over each other will be ſufficient to repreſent the ſtrongeſt ſhades.

To give theſe pieces the different motions they require, you muſt firſt conſider the nature of each piece: if, for example, you have cut out the figure of the ſun, as Plate XXX. Fig. 5, or of a ſtar as Fig. 6, you muſt conſtruct a wire wheel of the ſame diameter with thoſe pieces, in the manner repreſented in Fig. 7.† over this wheel you paſte a very thin paper, on which is drawn, with thick black ink, the ſpiral figure repreſented by Fig. 8. The wheel thus prepared, is to be placed behind the ſun or ſtar, in ſuch manner that its axis may be exactly oppoſite the center of either of thoſe

* There ſhould not be a very great diverſity of colours, as that would not produce the moſt agreeable appearance.

† This wheel is made of wire, that its radii, by being ſmall, may not intercept the light that is to be placed behind it.

thoſe figures. This wheel may be turned by any method you think proper.

Now, the wheel being placed directly behind the ſun, for example, and very near to it, is to be turned regularly round, and ſtrongly illuminated by candles placed behind it. The lines that form the ſpiral will then appear, through the ſpaces cut out from the ſun, to proceed from its center to its circumference, and will reſemble ſparks of fire that inceſſantly ſucceed each other. The ſame effect will be produced by the ſtar, or by any other figure where the fire is not to appear as proceeding from the circumference of the center.

Theſe two pieces, as well as thoſe that follow, may be of any ſize, provided you obſerve the proportion between the parts of the figure and the ſpiral, which muſt be wider in larger figures than in ſmall. If the ſun, for example, have from ſix to twelve inches diameter, the width of the ſtrokes that form the ſpiral need not be more than one-twentieth part of an inch, and the ſpaces between them, that form the tranſparent parts, about two tenths of an inch. If the ſun be two feet diameter, the ſtrokes ſhould be one-eighth of an inch, and the ſpace between one quarter of an inch; and if the figure be ſix feet diameter, the ſtrokes ſhould be one quarter of an inch, and the ſpaces five-twelfths of an inch. Theſe pieces have a pleaſing effect when repreſented of a ſmall ſize, but the deception is more ſtriking when they are of large dimenſions.

It will be proper to place theſe pieces, when of a ſmall ſize, in a box quite cloſe on every ſide, that none of the light may be diffuſed in the chamber: for which purpoſe it will be convenient to have a tin door behind the box, to which the candleſticks may be ſoldered, and the candles more eaſily lighted.

The ſeveral figures cut out ſhould be placed in frames, that they may be put alternately, in a groove in the fore part of the box: or there may be two grooves, that the ſecond piece may be put in before the firſt is taken out. The wheel muſt be carefully concealed from the eye of the ſpectator.

Where

Where there is an opportunity of repreſenting theſe artificial fires by a hole made in a partition, they will doubtleſs have a much more ſtriking effect, as the ſpectator cannot then conjecture by what means they are produced.

To repreſent fires that flow from the circumference to the center, as BB, &c. (Plate XXX. Fig. 9) and at the ſame time others that flow from the center to the circumference, as A, A, &c. you muſt conſtruct the double ſpiral repreſented by the 10th figure of the ſame plate.

When this wheel is placed behind Fig. 9, the concentric ſpiral A, Fig. 10. being oppoſite the parts A, Fig 9, the fire will appear to iſſue from the center, as before: but the parts againſt the excentric ſpiral of the wheel B, Fig. 10, which are thoſe marked B, in Fig. 9, will appear to move from the circumference to the center.

It is eaſy to conceive that by extending this method, wheels may be conſtructed with three or four ſpirals, to which may be given different directions, as in Plate XXXI. Fig. 1. where is drawn, on the tranſparent piece, the ſpirals that are proper to produce, not only jets de feu, but alſo ſmall pyramids, as A, A, &c. which will appear to turn on their centers It is manifeſt alſo, that on the ſame principle, a great variety of tranſparent figures may be contrived, and which may be all placed before the ſame ſpiral lines.

RECREATION CIX.

To repreſent caſcades of fire.

IN cutting out caſcades you muſt take care to preſerve a natural inequality in the parts cut out, as is expreſſed in Plate XXXI. Fig. 3. for if to ſave time, you ſhould make all the holes with the ſame pointed tool, the uniformity of the parts will not fail to produce a diſagreeable effect. As theſe caſcades are very pleaſing when well executed, ſo they are highly diſguſtful when

when imperfect. Theſe are the moſt difficult pieces to cut out.

To produce the apparent motion of theſe caſcades, inſtead of drawing a ſpiral, you muſt have a ſlip of ſtrong paper as ABCD, (Plate XXXI. Fig. 2.) of ſuch length as you judge convenient. In this paper there muſt be a great number of holes near each other, and made with pointed tools of different dimenſions.

At each end of the paper a part, of the ſame ſize with the caſcade, muſt be left uncut: and towards thoſe parts the holes muſt be made at a greater diſtance from each other, as is expreſſed in the figure. This paper is to be fixed by its two extremities, to the two rollers A and B, Fig. 3.

When the caſcade that is cut out is placed before the ſcroll of paper juſt mentioned, and it is entirely wound upon the roller A, the part of the paper that is then between E and B, being quite opaque, no part of the caſcade will be viſible. But as the winch D is turned gently and regularly round, the tranſparent part of the paper proceeding from A to B, will give to the caſcade the appearance of fire that deſcends in the ſame direction: and the illuſion will be ſo ſtrong that the ſpectators will think they ſee a caſcade of fire: eſpecially if the figure be judiciouſly cut out.

A caſcade may be alſo tolerably well executed by a ſpiral, in the manner expreſſed in Fig. 4: but the roller is more eligible. The paper being totally rolled on B, the part between A and B will be quite opaque: therefore the caſcade may be then taken away, and another piece, which repreſents fire that aſcends, as a jet, may be placed in its room: and thus the pieces may be alternately, and continually changed.

RECREATION CX.

Imitative illuminations.

ON a very ſtrong, double paper, whoſe backſide is blacked with ſoot, diſſolved in brandy, and to which a little gum arabic is added, you muſt firſt paint the draught

Fig. 1.

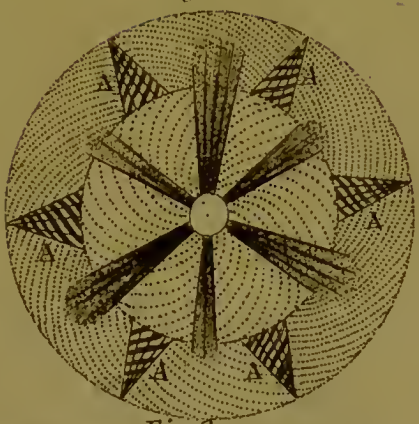


Fig. 2.

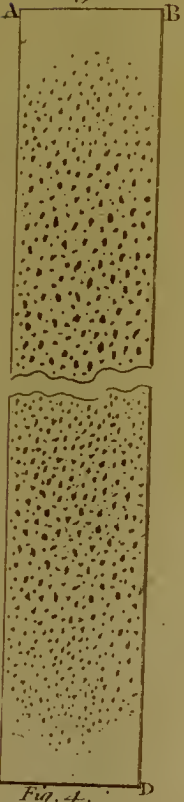


Fig. 3.

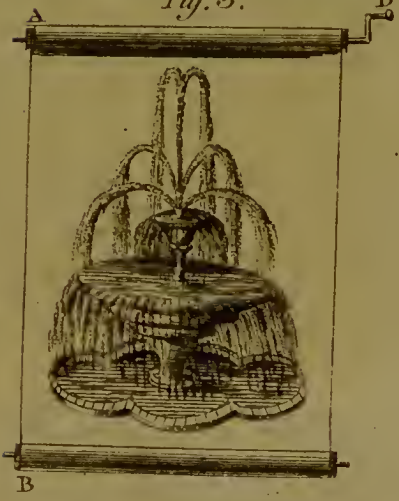


Fig. 4.



draught of the illumination you intend to repreſent in miniature, and mark the exact place of the ſeveral lamps and other parts that compoſe it. Then take piercers of different ſizes, with which make holes in the papers, in ſuch form as ſhall repreſent the flame of a lamp or other body. If the lamps are ſuppoſed to be all in a line, you muſt uſe the fineſt piercers for the ſmalleſt lamps, and the larger for the greateſt: but if the parts of the illumination be ſuppoſed at different diſtances, then the fine piercers are to be uſed for thoſe parts that are moſt diſtant, and the holes muſt be nearer together, in proportion to the diſtance. If there be objects in front perpendicular to the point of view, you muſt uſe piercers whoſe diameters decreaſe inſenſibly, and make the holes continually cloſer, in proportion as the extremities of the front are more diſtant. It is not material, in this caſe, whether the points be cloſe together, provided the perſpective be obſerved.

When the piece is completely cut out, you place behind this double paper one that is very thin; obſerving to colour the parts that are to appear the moſt diſtant with a little carmine diluted in water.* It is then to be placed in a box, and ſtrongly illuminated behind by ſeveral candles or lamps placed at equal diſtances from each other, that all the parts may be equally illuminated†: for otherwiſe the illuſion will not be complete. The front of the paper ſhould be alſo illuminated with a faint light, ſuch as is juſt ſufficient to ſhow the pieces of architecture that may be painted on it.

After the manner above deſcribed, prints alſo of every kind, may be cut out, and placed in any optical machine, except ſuch as have an inclined mirror, for there the print being naturally placed in a horizontal

 direction,

* This circumſtance is neceſſary, for the more diſtant natural illuminations are, the more red they appear.

† The candles ſhould be placed not cloſe to the paper, but at five or ſix inches diſtance, and if they do not produce a light ſufficiently ſtrong, you may place more. It will be proper to line the box with tin, as that will reflect the light on the piece.

direction, it will be difficult to illuminate it sufficiently to produce any remarkable effect. If you are desirous, however, of making an experiment with a print in a horizontal position, instead of placing a transparent paper behind it, you must put one that is gilt, which is to appear through the parts cut out. A print thus prepared, when a strong light is thrown upon it, will represent an illumination tolerably well.

APPENDIX.

APPENDIX.

Several of the Recreations in this Appendix have, in fact, but little relation to experimental philoſophy, eſpecially thoſe that depend on a dexterous manœuvre; but as experiments of this kind are commonly found in books of mathematical recreations, it ſeemed requiſite to inſert ſome of the moſt entertaining among them at the end of this treatiſe.

CHYMICAL TRANSMUTATIONS.

AMONG the moſt pleaſing as well as ſurpriſing phenomena of nature, may be juſtly ranked the tranſmutations produced by chymiſtry, eſpecially thoſe of colours; and recreations of this kind are the more pleaſing, as they are, for the moſt part, eaſily executed.

RECREATION CXI.

Tranſcolourations.

TAKE antimony and grind it to a powder, and it will become black. Let it be calcined with aqua regia, and it will be of a greeniſh yellow; white, red, yellow, greeniſh and black, when ſublimed with ſal ammoniac; of an uniform red, when freed from its ſalt by water; but white when fixed with thrice its weight of nitre. Thus you have almoſt all the colours in one ſolid body. Mercury diſſolved by aqua fortis, and diſtilled in a glaſs retort, affords likewiſe, in different parts of the glaſs, a variety of colours.

To make a gold colour by mixing a limpid liquor with a grey powder: pour hot alcohol on ſulphur, melted with fixed alkali, then ground and heated. To

change this gold coloured liquor into one of the colour of milk, by pouring it into a clean glaſs: let the glaſs be previouſly rinſed with oil of vitriol.

To turn an almoſt limpid liqour blue: pour ſpirit of ſal ammoniac to a ſolution of verdigreaſe in vinegar, and dilute it with water till it be almoſt limpid. To turn that blue liquor pellucid, add acid to it, till the acid predominate.

To turn a very green liquor of a beautiful violet colour: to a high green ſolution of copper in vinegar, drop ſpirit of ſal ammoniac, till the alkali predominate.

To turn a blue into a beautiful green. To a rich ſolution of copper in ſpirit of ſal ammoniac, add vinegar, or any other acid, till the acid preponderate.

To produce numerous blues and greens, between a deep blue and deep green: put a ſtrong and hot ſolution of copper in ſal ammoniac, into a clean cylindrical glaſs, and add thereto, ſlowly, ſpirit of nitre, drop by drop. A different colour, between the two degrees, will appear upon the addition of each other.

RECREATION CXII.

To make a colourleſs liquor black, by pouring it into a clean glaſs.

RINSE a clean hot glaſs in a ſtrong ſolution of the vitriol of iron; then pour out into a warm infuſion of bruiſed white galls in fair water, made ſo weak as ſcarce to afford any colour. This black mixture is inſtantly made. Inſtead of galls you may uſe red roſes, pomegranate bark, or tea, ſage, or oak leaves.

RECREATION CXIII.

To turn a pellucid liquor black, by adding to it a white powder.

PUT a hot weak pellucid infuſion of galls into a glaſs, throw into it a grain of the vitriol of iron calcined to whiteneſs, and heated: this, as it falls, makes a black

a black cloud, that diffuſes itſelf through the tranſparent liquor in a pleaſing manner, and gradually turns it black all round.

The ſame may be done with a pellucid drop: by putting a ſingle drop of the aqueous ſolution of the vitriol of iron into the hot ſolution of galls.

The ſame effect may alſo be produced by the addition of a little yellow or red powder; in the firſt inſtance by uſing vitriol calcined to a yellow colour; and in the other, by the colcothar of vitriol calcined to redneſs. To produce the ſame effect by a drop of gold coloured liquor, uſe the golden tincture made with the red calx of the vitriol of iron, and the dulcified ſpirit of ſalt.

In all theſe experiments, while the liquor is changing from limpid to deep black, there ariſe almoſt innumerable ſhades, or intermediate degrees of darkneſs, which at laſt all terminate in black.

The black liquor produced in all the preceding caſes, may be rendered pellucid again, by pouring the liquor hot into a glaſs rinſed with the pure oil of vitriol which attracts the iron. But the black liquor made with the calx of iron remains ſomewhat reddiſh, while it tends to tranſparency.

To make this tranſparent liquor black again, pour to it as much hot oil of tartar per deliquium, as will ſaturate the acid that has attracted the metallic matter. This is attended with an effervescence, which at the ſame time reduces, deſtroys, and regenerates, viciſſitudes of colours, which is beſt perceived by letting the alkaline liquor fall in at ſeveral times, but with a quick motion.

Laſtly, if a ſufficient quantity of acid be added to the black liquor thus regenerated, ſo as to aboliſh the alkali, the whole will become pellucid again; and this blackneſs may be reciprocally deſtroyed or reſtored. Hence alſo appears the ſurpriſing power of a metal to produce blackneſs, and how little matter is required to the production of colours.

RECREATION CXIV.

To produce different colours by pouring a limpid liquor in a clean glaſs.

TAKE a ſtrong ſolution of mercury made with ſpirit of nitre; dilute it with water, and pour it into a hot glaſs rinſed in a ſtrong ſpirit of ſea ſalt, and it will become coloured. A very dilute ſolution of ſilver, made in ſpirit of nitre poured into a glaſs prepared in the manner juſt mentioned, or the oil of antimony poured into a glaſs rinſed in hot water, will have the ſame effect.

To produce an orange colour, pour hot water upon new made crocus metallorum, and put it into a clean glaſs rinſed with any acid.

RECREATION CXV.

The colour that appears and diſappears by the influence of the air.

PUT into a decanter volatile ſpirit in which you have diſſolved copper filings, and you will have a fine blue tincture. If the bottle be ſtopped the colour will preſently diſappear, but when it is unſtopped the colour will ſoon return: and this experiment may be repeated a great number of times.

SYMPATHETIC INKS.

BY ſympathetic inks is meant, thoſe ſorts of liquors with which any characters being wrote, they remain inviſible, till ſome method is uſed to give them a colour. Theſe liquors are divided into five claſſes, and that with reſpect to the means uſed to make them viſible.

The firſt claſs of theſe inks are ſuch as become viſible by paſſing another liquor over them, or by expoſing them to the vapour of that liquor.

The ſecond are thoſe that do not appear ſo long as they

they are kept close, but become soon visible on being exposed to the air.

The third are such as are made apparent by strewing or sifting some very fine powder, of any colour, over them.

The fourth are those that will not be visible, till they have been exposed to the fire or heated.

The fifth, like the fourth, appear by heat, but disappear again when the paper becomes cold, or has had a sufficient time to imbibe the moisture of the air.

The compositions of the first class of these inks.

Impregnation of Saturn.

Put litharge of lead into strong distilled vinegar, and let it stand for twenty-four hours. Then strain it off, and let it remain till quite settled. Preserve this liquor in a bottle.

Dissolve orpiment in water of quick lime*, either by a sand heat, or by setting the bottle in the sun for two or three days, observing to turn it five or six times each day†.

In preparing these liquors you must take care that they have no communication; for the vapour of the latter is sufficient to destroy the limpidity of the other, and thereby render it unfit for use.

When the letters wrote by the first liquor are exposed to the vapour of the second, they become presently visible. If you would have them disappear again, you must draw a sponge or pencil, dipped in aqua fortis, or spirit of nitre over them. If after this you would have them appear again, let the paper be made quite dry by the air, and then pass the vivifying liquor, that is, the dissolution of orpiment, over them again.

Another

* Put in a pint bottle two ounces of quick lime, one ounce of orpiment in powder, and as much water as will rise two or three fingers above them. When the dissolution is made, pour the liquor gently off.

† The vapour of this liquor should be kept from the mouth, as it is highly pernicious.

Another ink of this claſs.

Diſſolve biſmuth in the nitrous acid. The letters wrote with this ink will become quite black by being expoſed to the vapour of the liver of ſulphur, which is of ſo penetrating a nature that it will act upon the ink through a quire of paper, or even the ſlight partition of a room.

Sympathetic gold ink.

Put as much gold into a ſmall quantity of aqua regia as it will diſſolve, and then dilute it with two or three times as much diſtilled water.

Diſſolve, in a ſeparate veſſel, fine pewter in aqua regia, and when it is well ſaturated, add to it an equal quantity of diſtilled water.

Let the characters you write with the diſſolution of gold become quite dry, in the ſhade, and they will not appear for the firſt ſeven or eight hours. Dip a pencil, or ſmall fine ſponge, in the diſſolution of pewter, and drawing it lightly over the inviſible characters, they will preſently appear of a purple colour.

The extraordinary effect of this ſympathetic ink is an exception to the general chemical principles, for we here ſee two metallic ſubſtances, change their colour by mixture, without any apparent fermentation.

The purple colour of the letters may be effaced, by wetting them with aqua regia; and it may be produced a ſecond time by paſſing the diſſolution of pewter over them again. This diſſolution of gold in aqua regia, as well as that of ſilver in the nitrous acid, being diluted by a ſufficient quantity of water, will likewiſe ſerve to write letters that will diſappear when they become dry, if they be carefully kept from the open air: but will be viſible after being expoſed an hour or two to the ſun or the fire.

Another ſympathetic ink.

Diſſolve green vitriol in common water, and add a ſmall quantity of nitrous acid; to prevent that yellow-

ith

ith precipitation that will otherwiſe be formed. The characters wrote in this diſſolution with a new pen will be viſible.

Infuſe water, or white wine, ſmall Aleppo galls, lightly bruiſed*. At the end of two or three days pour the infuſion cleanly off. By drawing a pencil dipped in this infuſion over the letters wrote with the laſt diſſolution, they will appear of a beautiful black, eſpecially if the infuſion be ſtrong.

The letters wrote with the laſt diſſolution will become a fine blue, if they be wetted with water ſaturated with Pruſſian blue: and letters wrote with this water, which will be inviſible, will likewiſe turn to a fine blue, by being wetted with the above diſſolution.

RECREATION CXVI.

The book of fate.

MAKE a book of ſeventy or eighty leaves, and in the cover at the end of it let there be a caſe, which opens next the binding, that it may not be perceived.

At the top of each right hand page write any queſtion you pleaſe, and at the beginning of the book let there be a table of all thoſe queſtions, with the number of the page where each is contained. Then write with common ink, on ſeparate papers, each about half the ſize of the pages in the book, the ſame queſtions that are in the book, and under each of them write, with the ink made of the impregnation of Saturn, or the diſſolution of biſmuth, the anſwer.

Soak a double paper in the vivifying ink made of quick lime and orpiment, or the phlogiſton of the liver of ſulphur, and place it, juſt before you make the experiment, in the caſe that is in the cover of the book.

Then deliver ſome of the papers on which the queſtions are wrote to the company, and after they have choſe ſuch as they would have anſwered, they put them in thoſe leaves where the ſame queſtions are contained, and

* You may put three-fourths of a pint of water or wine to two ounces of galls.

and ſhutting the book for a few minutes, the ſulphureous ſpirit with which the paper in the cover of the book is imbibed, will penetrate the leaves, and make the anſwers viſible, which will be of a brown colour, and more or leſs deep in proportion to the time the book has been cloſed*.

RECREATION CXVII.

The marvellous portrait.

MAKE a box about four inches long, and three wide, as ABCD, (Plate XXXII. Fig. 5.) and quite ſhallow. Let it ſhut with hinges and faſten with a hook; and let it have two bottoms, the loweſt of wood, that draws out by a groove, and the uppermoſt of paſteboard. Between theſe two bottoms is to be placed a paper dipped in the vivifying ink mentioned in the laſt Recreation. Let there be alſo a board of the ſame ſize with the inſide of the box, which being placed in it may preſs a paper againſt the paſteboard bottom.

Then take ſeveral pieces of paper, of the ſame ſize with the inſide of the box, and draw on them the figures of men and women, in different attitudes and employments, as walking, riding, reading, writing, &c. Theſe figures muſt be drawn with a new pen or pencil, dipped in the impregnation of Saturn.

Being thus provided, and having privately placed the paper dipped in the vivifying ink between the two bottoms, you tell a perſon you will ſhow him what an abſent friend of his is doing at the preſent hour. You then give him the paper adapted to the employment you intend, and tell him to write his friend's name at the bottom, that you may not change the paper. Then placing that paper next the paſteboard bottom, and putting the piece of wood over it, you ſhut the box. After amuſing him with diſcourſe for three or four minutes,

* If a weight be placed upon the book, the effect will be the ſooner produced. Or you may put the book in a box that will preſs it cloſe down.

Fig. 1.



Fig. 4.



Fig. 6.

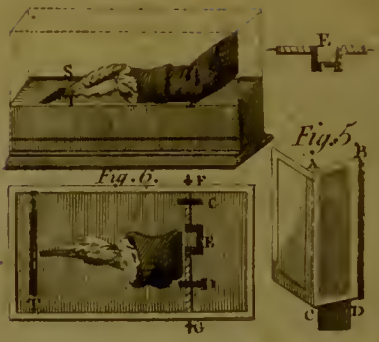


Fig. 2.

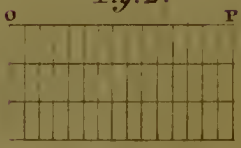


Fig. 7.

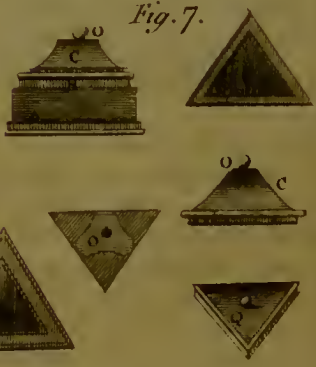
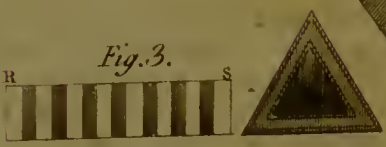


Fig. 3.



nutes, you take out the paper, when he will ſee his friend in the employment you have aſſigned him.

RECREATION CXVIII.

The artificial hand.

LET a workman make a hand of wood, (Plate XXXII. Fig. 6.) fixed at the end next the elbow to the piece E, the ends of which go through the ſcrews CF and DG. The fore and middle fingers, and the thumb, are to be moveable at their joints. There muſt go a wire through the arm, that is fixed at one end to the fore finger, and at the other to the piece E, round which it is to move: under the two joints of the two fingers are alſo placed two ſmall ſprings, which are to raiſe it up.

To the fore finger and thumb fix two ſmall rings, through which a pen may be put, ſo as not to impede their motion. Under the arm, at the point I, place a ſmall braſs roller, which ſerves to ſuſtain the arm.

The pedeſtal on which this hand is placed muſt be at leaſt a foot long, if the hand be of the natural ſize, and about eight inches wide. This pedeſtal muſt be hollow, and at the part S T there muſt be an opening about three inches long and two inches wide; the whole pedeſtal may be covered with a thin ſtuff, by which the hole will be concealed. There is to be a valve, or ſort of trap-door, on the inſide of the pedeſtal, which is to faſten againſt the opening.

Over the hand and pedeſtal place a glaſs frame, as in the figure: cover the hand with fine leather of fleſh colour, and decorate the arm with a ruffle and cuff, which will entirely conceal the machinery.

Then take a number of cards and write on them different queſtions, and on the ſame number of papers write, with the impregnation of Saturn, the anſwers. Give the cards to any one, and let him chooſe a queſtion, and you place the paper with the anſwer under the pen in the hand, letting him firſt ſee there is no writing

writing on it*. Now the pedeſtal being placed againſt a partition, the end F is to go through it. Therefore an aſſiſtant, upon a ſignal given, turns a handle fixed to F, and as the piece E turns round the wires that moves the fingers and thumb are alternately lengthened and ſhortened, by which their joints are kept in continual motion; and the ſcrew at the ſame time turning gently from F towards G, gives the whole arm a motion which very much reſembles that of nature†.

The hand and pen ſerve here merely to aſſiſt the illuſion: but if a bit of ſponge, dipped in the vivifying ink, be placed at the end of the pen, as it goes over the writing on the paper, it will make it become gradually viſible, and in this caſe the trap door and dipped paper may be omitted‡.

Sympathetic inks of the ſecond claſs.

The ſympathetic ink of gold, of which we have already given the compoſition, is alſo of this claſs; for without paſſing the diſſolution of copper over it, when it is only expoſed to the air an hour or two it becomes by degrees of a deep violet colour, that nearly approaches black.

But if inſtead of expoſing it to the air, you keep the paper on which it is wrote in a box ſhut cloſe, or wrapt up in another paper, it will remain inviſible for three or four months, but after that time it will become of a deep violet colour§.

Sympathetic

* A paper dipped in the vivifying liquor is to be previouſly placed againſt the opening in the table, and ſupported by the trap-door.

† This might be performed without an aſſiſtant, by means of a trigger placed in the leg of the table, and communicating with the handles, which the operator might thruſt down with his foot. Where expence is not regarded, there may be a complete figure of a man in wood, or plaſter of Paris, ſeated by the table.

‡ You may alſo have a glaſs ink-ſtand, with ſome of the vivifying liquor, into which the pen may be dipped, and it will then appear to write with common ink. The ſpectators ſhould not be permitted to come very near this machine, which may be applied to ſeveral other purpoſes.

§ If in writing it make yellow ſpots on the paper, you muſt add to it a little common water.

Sympathetic ſilver ink.

Diſſolve fine ſilver in aqua fortis, and after the diſſolution add ſome diſtilled water, in the ſame manner as in the gold ink. What is wrote with this ink, will remain inviſible for three or four months, if it be kept quite cloſe from the air, but will appear in an hour if expoſed to the ſun, and will be of a grey colour, like that of a ſlate.

Under this ſecond claſs of ſympathetics may be alſo included ſeveral other diſſolutions of metals, ſuch as lead by vinegar, copper by aqua fortis, which gives the colour of tan on the paper; pewter by aqua regia; emery and certain pyrites, in ſpirit of ſalt; mercury in aqua fortis; or iron by vinegar. Each of theſe diſſolutions expoſed to the air have a particular colour; but they have the diſagreeable quality of rotting the paper, ſo that after a certain time the characters appear like holes, in the ſame manner as if they had been cut out; they are therefore fit only for extempore recreations.

RECREATION CXIX.

The writing againſt the wall.

TAKE ſeveral pieces of paper, of a ſize that you can put in any book that will go into your pocket, and write at the top of each of them a queſtion, with common ink, and under it write the anſwer with the gold or ſilver ink juſt mentioned. Give any one of theſe papers, cloſely wrapt up, to a perſon, and tell him to place it againſt the wall of his chamber, and keeping the door locked he will next day find the anſwer wrote on it.

As the gold ink will ſometimes give a yellow caſt to the paper, you may previouſly give a ſlight tincture of that kind to the papers you uſe for this purpoſe.

RECREATION CXX.

The taliſman.

MAKE a little triangular box, (Plate XXXII. Fig. 7.) each ſide of which is to be about five inches, and let its inſide be divided into three parts. The firſt part A, which makes the bottom of the box, is to be covered by the ſecond part B, in form of a caſe, and let the top C, exactly cover the part B; as is expreſſed in the figure and the profiles.

Upon the bottom of the box let there be a plate of copper, about one-twentieth of an inch thick, on which let there be a number of hieroglyphic characters, contiguous to each other, and cut in different ſorts of metal.

On the top of the cover place a knob O, that goes through it, and to which the copper triangle Q is to be fixed occaſionally, in ſuch manner as it may go into the caſe B. There muſt be a ſpace of one quarter of an inch between the triangle Q, and the bottom of the caſe B; into which another plate of copper, of that thickneſs, may be placed.

The outſide of this taliſman may be decorated with uncommon figures or characters, to give it the appearance of greater myſtery.

On ſeveral pieces of paper, of the ſame ſize with the inſide of the taliſman, write different queſtions, in common ink, and write the anſwers in thoſe different ſorts of ſympathetic ink, that appear when heated, obſerving that each word of the anſwer is to be wrote in a different ink*.

Having properly heated the triangle, and placed it under the cover, you introduce the taliſman, and tell any one of the company to chooſe one of the papers on which the queſtions are wrote, and place it in the taliſman, and he will immediately have an anſwer wrote on that paper, the words of which will be of different colours, according to the different metals of which

* The inks proper for this purpoſe will be deſcribed further on.



Fig. 1.

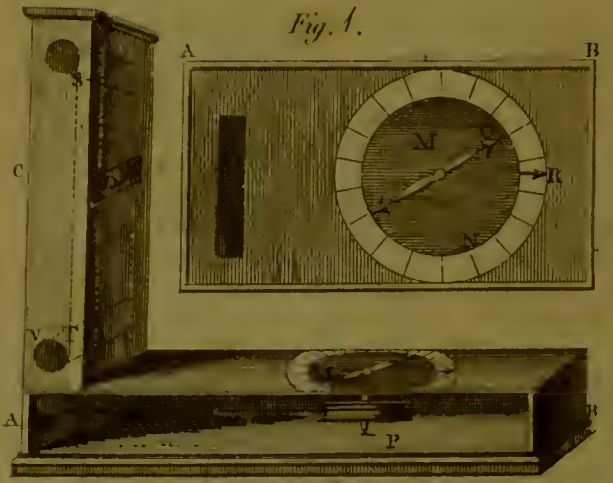


Fig. 2.



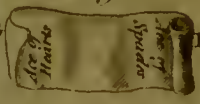
Fig. 3.



Fig. 7.



Fig. 6.



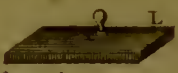
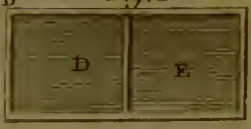


Fig. 4.



Fig. 5.



which the talisman is composed. The paper being placed in the talisman, and the cover placed over it, the heat of the triangle will make the answer visible in a few moments. This Recreation may be repeated if the triangle be made sufficiently hot; and two papers may be placed in the talisman at the same time.

This Recreation, when well executed, occasions a surprize that cannot be conceived by a mere description.

RECREATION CXXI.

The sibyls.

MAKE a wooden pedestal A B, (Pl. XXXIII. Fig. 1.) about ten inches long, eight wide, and one deep: and at one end erect a box C, about ten inches high, eight broad, and two and a half deep.

The top of the pedestal must slide in a groove, on which inscribe a dial M, of six inches diameter, which is to be divided into nineteen parts; in twelve of which write the names of the months, and mark the respective signs of the zodiac and in the seven other divisions, which must be next the end B, write the days of the week, and mark the figures of the planets. Next the inner circle N O, make an opening into the box of about one-tenth of an inch. On the center of the dial, place an index M, that turns freely on its center.

Within the pedestal place a pulley P, about four inches diameter, which is to turn on an axis that is directly under the center of the dial, and on the upper part of that axis fix a bent index R, which comes out at the opening made by the inner circle*, and passes over those seven divisions only, on which are wrote the days of the week.

Within the box C, let there be two rollers S, and T, as in the figure: let that of S contain a spring, and at the end of T let there be a pulley V of three quarters of an inch diameter, round which goes a string

* If the axis be made to pass through the top of the pedestal, this opening will not be necessary.

or thread that paſſes under the ſmall pulley X, and is faſtened to that of P: ſo that when the laſt pulley makes about one-third of a turn, that of V may make the three or four turns.

There muſt be alſo a ſcroll of paper, about two feet long, and each end of which muſt be paſted to one of the rollers. In the front of the box between the two rollers, make an aperture D, about four inches long, and one inch and a half wide: to this opening let there be a little flap or ſlider, by which it may be cloſed at pleaſure.

The apparatus being thus diſpoſed, place the index R ſucceſſively againſt each of the diviſions marked with one of the planets, and as the paper is gradually wound up the roller, mark againſt that part which is at the aperture D, the name of one of the following ſibyls.

The Helliſpontian
Cumean
Artemiſian
Phrygian
Albunean
Tiburtian
Lybian

} ſibyl.

On each of the ſeven cards write a different queſtion, and draw one of the ſeven planets. Next, take a memorandum book, that contains ſeven leaves, and on each of them write the name of one of the foregoing ſibyls; in each of the leaves place ſeveral pieces of paper, and on each of them write, with the ſympathetic ink that does not appear till the paper is heated, different anſwers to the ſame queſtions.

Then give a perſon the ſeven cards on which the queſtions are wrote, and tell him to chooſe one of them privately, and conceal the reſt, ſo that it cannot poſſibly be known which of them he has choſe.

Next tell him to place the index that points to the month againſt that in which he was born*, and to place

* Theſe months and the index are of no other uſe than to give the experiment an air of greater myſtery.

place the index of the planet againſt that which is on the card he has choſe, and which is to preſide over the anſwer: you tell him to do this privately, that no one may ſee him, and after that to cover the dial with his handkerchief. Then let him open the door that is before the aperture in the box, and tell you the name of the ſibyl there viſible.

You then open the memorandum-book, and taking out the papers that are in the leaf where the name of the ſibyl juſt mentioned is wrote, you deſire him to chooſe any one of them he thinks proper. The taliſman uſed in the laſt Recreation being properly heated, is then to be introduced, when you direct the perſon to put the blank paper into it, and taking it out a few moments after, he will find the anſwer to his queſtion.

To make this operation appear the more extraordinary, it will be proper to have a ſmall preſs or cupboard, at the back of which there is a door that opens into an adjoining room, by which means an aſſiſtant having prepared the taliſman may place it in the cupboard the moment before it is wanted. This contrivance will be uſeful on many other occaſions.

RECREATION CXXII.

The magic urn.

PROVIDE an urn of wood or metal about ſix inches high and two and a half diameter in the wideſt part, and of ſuch figure in other reſpects as you think proper (ſee Pl. XXXIII. Fig. 2.) Let there be a cylinder of copper C, Fig. 3. of about one-eighth of an inch diameter, which is to fill a hole AB, made in the urn. The top of this cylinder is to be in the top of the urn, ſo that it may be eaſily taken out. To this urn there muſt be a cover D, which fits it exactly.

On a ſmall ſquare piece of paper draw the figure of a flower or leaf, with that ſort of ſympathetic ink, whoſe colour moſt reſembles it. You then preſent ſeveral ſorts of flowers or leaves to a perſon, and deſire him to chooſe any one of them. Then put that flower

on a chafing-dish of hot coals, and taking the paper on which it is secretly drawn, you give it to the person to examine, and then put it in the urn, having previously heated the cylinder*. Then taking some of the ashes of the burnt flower, you strew them over the paper, after which you take it out and shew the company the figure of that flower. While the flower is burning you may sprinkle some powder over it, suppose that of saltpetre, and by that, mixed with the ashes of the flower, the company may imagine the effect is produced.

The press or cupboard mentioned in the last Recreation will be here very convenient for heating the cylinder and placing it in the urn. A similar Recreation may be performed by putting the paper in a copper vessel, that may be placed on an iron plate over the chafing-dish in which the flower is burnt. But this method has not so mysterious an appearance as the other, and in some persons may cause a suspicion that the effect is produced by heat.

Other sympathetic inks.

Beside those mentioned in the beginning of this article there are several other inks which appear very lively when a coloured liquor is passed lightly over them, of which the following are the most material.

A yellow sympathetic ink is made by steeping the flowers of the marygolds seven or eight days, or more, in clear distilled vinegar, and then pressing them out. The liquor is to be kept in a bottle well corked. If you would have it still more limpid, add at the time of using it some clear water.

For a red invisible ink; to the pure spirit of vitriol or that of nitre, add eight or ten times as much water, as you would have it more or less red.

For a green ink of this sort, dissolve salt of tartar, the clearest, and driest you can procure, in a sufficient quantity of river water.

For

* There are some sorts of sympathetic inks that require much more heat than others.

For a violet ſympathetic ink, expreſs the juice of lemons and keep it in a bottle well corked.

All that is wrote on paper, or any white body, ſuch as ſilk, cloth, &c. with one of thoſe inks, will appear of the colour above expreſſed, after it has been dipped in the following liquor. Take a ſufficient quantity of the flowers of paney, or of the common violet, and bruiſe them in a mortar, adding ſome water to them, and ſtraining the liquor through a cloth, keep it in a bottle; or take water in which turnſole has been ſteeped.

RECREATION CXXIII.

The revivified bouquets.

PROVIDE a number of artificial flowers, ſuch as roſes, jonquils, pinks, or any other you find convenient. Theſe flowers muſt be made of white thread or ſilk, and their leaves of parchment. Dip the roſes in the red ſympathetic ink, the jonquils in the yellow, the pinks in the violet, and their leaves in the green ink. When they are all dry form them into ſmall bouquets, which will all appear white and may be uſed in this Recreation, either the day they are dipped, or ſeveral days after.

You take one of theſe bouquets, and after ſhowing the company that every part of it is white, you dip it in the vivifying liquor made of violets, juſt deſcribed, and drawing it preſently out, all the flowers and leaves will appear in the natural colours*.

RECREATION CXXIV.

The tranſcolourated writing.

WRITE on a paper, with the violet liquor, as many letters or words as you pleaſe; and aſk any perſon

* The vivifying liquor ſhould be put in a ſort of jar, with a narrow neck, that it may not be ſeen by the company; and you ſhould draw the flowers gently out, that the liquor may drop, if then, and they may have time to acquire their colours.

ſon whether he will have that writing turn to yellow, green, or red.

Have a ſponge with three ſides that you can readily diſtinguiſh, and dip each of its ſides in one of the three ſympathetic inks. Draw the ſide of the ſponge that correſponds to the colour the perſon has choſe, over the writing once only; and it will directly change to the colour required*.

Sympathetic inks of the third claſs.

Theſe, as we have ſaid, are ſuch as become viſible by having any fine powder ſtrewed over them, and may be compoſed of the glutinous and colourleſs juice of any vegetable, the milk of animals, and many other ſubſtances.

RECREATION CXXV.

Magical vegetations.

ON different papers draw the figures of ſeveral leaves or flowers with one of the colourleſs juices above mentioned: then take one of the correſponding leaves or flowers, and laying it on an iron plate over a chafing-diſh of hot coals, let it burn to aſhes. Put theſe aſhes into a ſieve, in which there is ſome very fine ſteel filings, and ſift them over the paper on which the flower is drawn, when they will adhere to the glutinous liquor, and form an exact repreſentation of the figure of the leaf or flower.

Sympathetic inks of the fourth claſs.

This claſs, comprehending all thoſe that become viſible by being expoſed to the fire is very extenſive, as it contains all thoſe infuſions and diſſolutions, in which the matter diſſolved is capable of being reduced into a ſort of charcoal by a ſmall heat. A few examples of theſe inks will here ſuffice, and the rather, as moſt of thoſe

* The ſponge ſhould be well cleaned immediately after the experiment.

thoſe of the firſt claſs which appear on being expoſed to the air, are of this claſs likewiſe.

Theſe inks may be made by a ſtrong diſſolution of vitriol in common water, or of the juice of lemons or onions; the two latter requiring leſs heating than the firſt, but they will not keep ſo long.

RECREATION CXXVI.

The tranſmutable cards.

IN a common pack of cards, let the ace of hearts and nine of ſpades be ſomething larger than the reſt. With the juice of lemon drawn over the ace of hearts a ſpade, large enough to cover it entirely, and on each ſide draw four other ſpades.

Preſent the pack to two perſons, ſo adroitly, that one of them ſhall draw the ace of hearts and the other the nine of ſpades, and tell him who draws the latter, to burn it on a chafing-diſh. You then take the aſhes of that card, and put them into a ſmall metal box, and give it to him who has the ace of hearts, that he may himſelf put that card into the box and faſten it. Then put the box for a ſhort time on the chafing-diſh, and let the perſon who put the card in it, take it off and take out the card, which he will ſee is turned to the nine of ſpades*.

RECREATION CXXVII.

The convertible cards.

TO perform this Recreation you muſt obſerve that there are ſeveral letters which may be changed into others, without any appearance of the alteration; as the *a* into *d* the *c* into *a*, *e*, *d*, *g*, *o*, or *q*, the *i* into *b*, *d*, or *l*, the *l* into *t*, the *o* into *a*, *d*, *g*, or *q*, the *v* into *y*, &c.

Take

* In making this experiment the chafing-diſh ſhould not be brought into the room till the two cards are drawn that if the parties ſhould not draw thoſe cards you may exhibit ſome other recreation.

Take a parcel of cards, ſuppoſe 20, and on one of them write, with the ink of the fourth claſs the word *law**, and on the other, with the ſame ink, the words *old woman*; then holding them to the fire they will both become viſible. Now you will obſerve that by altering the *a* in the word *law* into *d*, and adding *o* before the *l*, and *oman* after the *w*, it becomes *old woman*. Therefore you make thoſe alterations with the inviſible ink, and let it remain ſo. On the reſt of the cards you write any words you think fit.

Preſent the cards in ſuch manner to two perſons, that one of them ſhall draw the word *law*, and the other the words *old woman*. You then tell the perſon who drew the word *law*, that it ſhall diſappear, and the words on the other card ſhall be wrote in its place: and that you may not change the cards, deſire each of the parties to write his name on his card. Then putting the cards together, and holding them before the fire, as if to dry the names juſt wrote, the word *law* will preſently change into *old woman*.

This Recreation may be varied by fixing on a word that may be changed into three other words, and making four perſons draw the cards on which thoſe words are wrote; and it may be further diverſified by chooſing three ſuch words, as that the firſt can be changed into the ſecond, and the ſecond into the third. You then tell him who drew the firſt word, that it ſhall be changed into that drawn by the ſecond perſon; and him you tell, that his word ſhall be changed into that of the third perſon.

RECREATION CXXVIII.

The oracular letters.

WRITE on ſeveral ſlips of paper different queſtions, and ſuch as may be anſwered by the name of ſome perſon; for example, Who is the merrieſt man in the company? Anſwer, Mr ****. To whom will Miſs *** be married? Anſwer, To Mr ***. Theſe queſtions

* Theſe letters ſhould not be joined.

tions are to be wrote in the ſympathetic ink of this claſs, and expoſed to the fire, and the anſwers wrote in the ſame ink, and left inviſible. The papers are to be folded in the form of letters, and in ſuch a manner that the part where the name is wrote ſhall be directly under the ſeal, and the heat of the wax will make it viſible. Then give the letter to the perſon who requires the anſwer, and he will find it plainly wrote.

A recreation ſimilar to this may be made with a number of blank cards, on each of which an ace of ſpades is drawn with the inviſible ink; then let a perſon chooſe any one of them, and encloſe it in a letter-caſe, prepared in ſuch manner that the figure of the ace ſhall be directly under the ſeal, and on opening the letter it will be immediately viſible.

Sympathetic inks of the fifth claſs.

The green ink.

Take zaffre in powder, and let it remain for diſſolution in aqua regia during twenty four hours. Pour the liquor off clear, and add to it as much or more common water, and keep it in a bottle well corked.

This ink will not be viſible till it has been expoſed to the fire or to the ſtrong rays of the ſun. The characters will then be of a lively green. It is the peculiar property of this ink, that as ſoon as the paper becomes cold again the letters diſappear, and this alternate appearance and diſappearance may be repeated a great number of times, provided that by too great heat the letters never acquire the colour of fillemot, for after that they will never diſappear*.

RECRE-

* This ink may be alſo made of cobalt, in the manner deſcribed by M. Hellot, in the memoires de l'Academie des Sciences for 1737; but that method is far more embarraſſing to ſuch as are not uſed to chemical operations.

RECREATION CXXIX.

The incomprehenſible writing.

HAVE a box that is divided into three parts, after the ſame manner as the taliſman in the 120th Recreation, except that inſtead of being triangular, it muſt be of a long ſquare, (ſee Plate XXXIII. Fig. 4.) Divide its top B into two equal parts D and E, as in Fig. 5. and to the part D adjuſt a plate of copper L, about one quarter of an inch thick, and under both the plate L and the opening E, place a cloth. The upper part C muſt have a button by which it may be fixed on the cover B, ſo as to appear of one piece with it.

At the bottom of the box place a piece of cloth, or other ſtuff, on which you may ſtamp certain myſterious characters, and obſerve that the bottom of this cover muſt reſt upon the cloth.

Then provide a ſlip of paper GH, Fig. 6. of the ſame ſize with the bottom of the box, and at each end of it write, with the green ſympathetic ink, the name of a different card, and make ſome private mark, by which you can tell at which end each name is wrote*.

Take a parcel of cards, and offer thoſe two of them whoſe names are wrote on the paper to the two perſons, that they may draw them. You tell the parties to keep their cards to themſelves, and you propoſe to make the names of thoſe cards appear upon a ſlip of paper, which you put into the box. You then aſk which name of the two cards ſhall appear firſt. The copper plate being previouſly heated and placed in the cover, you put it over that end of the paper on which is the name required, and it will preſently appear. Then taking the paper out and ſhowing the name wrote, you put it in again, turning the other end to the

* That there may be no ſuſpicion of the papers being prepared, you may cut it from a whole ſheet, before the company, having previouſly wrote the names.

the ſide of the box where the plate is, and it will in like manner become viſible.

The firſt name may be made to diſappear at the ſame time that the ſecond appears, if the cloth at the end oppoſite to that where the plate is, be made damp.

RECREATION CXXX.

Winter changed to ſpring.

TAKE a print that repreſents winter, and trace over the proper parts of the trees, plants, and ground, with the green ſympathetic ink; obſerving to make ſome parts deeper than others, according to their diſtance. When thoſe parts are dry, paint the other objects with their natural colours. Then put the print in a frame with a glaſs, and cover the back of it with a paper that is paſted over its border only.

When this print is expoſed to the heat of a moderate fire, or to the warm rays of the ſun, all the graſs and foliage will turn to a pleaſing green, and if a yellow tint be given to ſome parts of the print, before the ſympathetic ink be drawn over it, this green will be of different ſhades; and the ſcene that a minute before repreſented winter, will now be changed to ſpring. When this print is placed in the cold, winter will again appear, and will again be driven away by the warm rays of the ſun. This alternate change of ſeaſons may be repeated as often as you pleaſe: remembering, however, as was before obſerved, not to make the print at any time too hot, for then a faded autumn will forever remain.

Sympathetic ink that appears by being wetted with water.

Mix alum with a ſufficient quantity of lemon juice. The letters wrote with this mixture will be inviſible till they are wetted with water, and then will appear of a greyiſh colour and tranſparent.

Or you may write with a ſtrong diſſolution of rock alum only, and when the writing is dry, pour a ſmall quantity of water over it, and it will appear of a white, like that of the paper before it was wetted.

All ſaline liquors, ſuch as vitriolic, nitreous, and marine acids, diluted with water; the liquor of fixed vegetable alkalis, and even vinegar, will produce the ſame effect.

When the paper is ſtrong and contains a ſufficient quantity of ſize, and the ſaline liquors are properly diluted, as, for example, when one ounce of aqua fortis is mixed with three or four ounces of water, the writing will dry well, become abſolutely inviſible, and not run out of its form when the paper is wetted. As the paper dries it will become again inviſible, and may be made to appear and diſappear many times.

This ſort of ink is very convenient, as it may be eaſily prepared with many ſubſtances that are readily procured, and as it does not require heating, nor the aſſiſtance of any other liquor, except common water*.

RECREATION CXXXI.

The oracular mirror.

PROVIDE a round mirror, (Pl. XXXIII. Fig. 7.) of about three inches diameter, and whoſe frame is an inch wide. Line the under part of the frame, in which holes are to be cut, with very thin glaſs; behind this glaſs let the mirror ABCD, of about two inches diameter, be placed, which is to be moveable, ſo that by inclining the frame to either ſide, part of the mirror will be viſible, behind the glaſs, on that ſide.

Then take Spaniſh chalk, or Cyprus vitriol, of which you make a pencil, and with this you may write on a glaſs and rub it off with a cloth, and by breathing on the glaſs the writing will appear and diſappear ſeveral times. With this pencil write on one ſide of the mirror, before it is put in the frame, the word *yes*, and on the other ſide, *no*; and wipe them off with a cloth.

You propoſe to a perſon to aſk any queſtion of this mirror that can be anſwered by the words *yes* or *no*. Then

* They who would amuſe themſelves further with theſe matters, may conſult a treatiſe wrote expreſsly on the ſubject, by that bright luminary in the Britiſh hemiſphere of ſcience, the ſagacious Boyle.

Then turning the glaſs to one ſide, and putting your mouth cloſe to it, as if to repeat the queſtion ſoftly, you breathe on it, and the word *yes* or *no* will immediately appear. This mirror will ſerve for many other agreeable amuſements.

RECREATION CXXXII.

The tree of Diana.

TAKE half an ounce of fine ſilver, either in filings or cut ſmall, and two drams of mercury, and diſſolve them in three or four ounces of aqua fortis. When the diſſolution is perfectly made, pour it into a pint of common water, and ſtir it about, that the whole may be well mixed. Keep this preparation in a bottle well corked.

In a ſmall phial put the quantity of a pea, of the amalgam of ſilver with mercury, and pour an ounce of the above liquor over it. There will preſently riſe from that little globular amalgam, ſmall branches, that by encreaſing will form a kind of ſhrub, or buſhy tree, of a ſilver colour.

Another way of producing this appearance is by diſſolving an ounce of fine ſilver in three ounces of ſtrong aqua-fortis, in a glaſs or earthen veſſel. When the ſilver is quite diſſolved, pour the aqua-fortis into another glaſs veſſel, wide at the bottom, with ſeven or eight ounces of mercury, and add one quart of common water: to the whole add your diſſolved ſilver, and let it remain untouched.

In a few days the mercury will appear to be covered with a multitude of little branches, reſembling ſlender ſhrubs, and of a ſilver colour. This appearance will continually increaſe for a month or two, and will remain after the mercury is entirely diſſolved*.

* It was very likely ſome experiment like this, together with a deception ſimilar to that uſed in a foregoing Recreation, that gave riſe to the pretended experiment of producing a tree or flower from its aſhes, which many have thought poſſible, and for the performing of which Paracelſus and Kircher have each of them given a regular proceſs, which ſerves only to ſhow what low arts and effrontery, have been practiſed by men of letters in ignorant ages.

RECREATIONS
OF
ADDRESS AND DEXTERITY.

RECREATIONS WITH THE CARDS*.

Previous to these recreations with the cards, it will be necessary to explain the method of *making the pass*: that is, bringing a certain number of cards from the bottom of the pack to the top; as many of these recreations depend on that manœuvre.

HOLD the pack of cards in your right hand, so that the palm of your hand may be under the cards: place the thumb of that hand on one side of the pack, the first, second, and third fingers on the other side, and your little finger between those cards that are to be brought to the top, and the rest of the pack. Then place your left hand over the cards, in such manner that the thumb may be at C, (Plate XXXIV. Fig. 1. and 2.) the fore-finger at A, and the other fingers at B.

The hands and the two parts of the cards being thus disposed, you draw off the lower cards confined by the little finger and the other parts of the right hand, and place them with an imperceptible motion on the top of the pack.

It is quite necessary, before you attempt any of the recreations that depend on making the pass, that you can perform it so dextrously that the eye cannot distinguish the motion of your hand; otherwise, instead of deceiving others you will expose yourself. It is also proper that the cards make no noise, as that will occasion suspicion. This dexterity is not to be attained without some practice.

We have mentioned in the first volume the method of preparing a pack of cards, by inserting one or more that

* Several of these recreations were invented by M. Guyot.

Fig. 6.



Fig. 1.

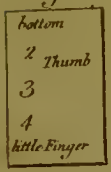


Fig. 2.



Fig. 3.



Fig. 4.



Fig. 5.



Fig. 7.



Fig. 8.



Fig. 10.

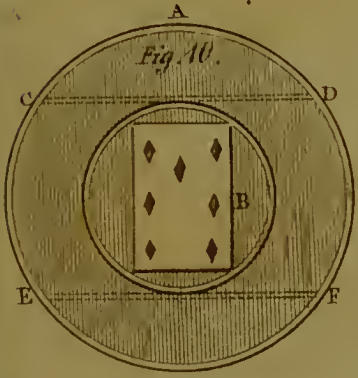
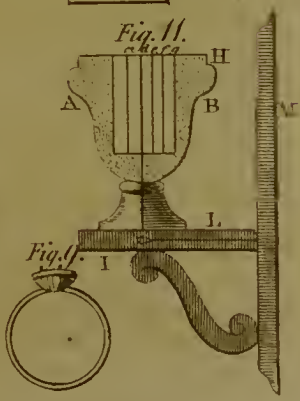


Fig. 11.



that are a ſmall matter longer and wider than the reſt, and that preparation will be neceſſary in ſeveral of the following recreations.

RECREATION CXXXIII.

The card of divination.

HAVE a pack in which there is a long card; open the pack at that part where the long card is, and preſent the pack to a perſon in ſuch a manner that he will naturally draw that card*. He is then to put it into any part of the pack, and ſhuffle the cards. You take the pack and offer the ſame card in like manner to a ſecond or third perſon; obſerving however, that they do not ſtand near enough to ſee the card each other draws. You then draw ſeveral cards yourſelf, among which is the long card, and aſk each of the parties if his card be among thoſe cards, and he will naturally ſay yes, as they have all drawn the ſame card. You then ſhuffle all the cards together, and cutting them at the long card, you hold it before the firſt perſon, ſo that the others may not ſee it, and tell him that is his card. You then put it again in the pack, and ſhuffling them a ſecond time, you cut again at the ſame card, and hold it in like manner to the ſecond perſon, and ſo of the reſt†.

If the firſt perſon ſhould not draw the long card, each of the parties muſt draw different cards; when cutting the pack at the long card, you put thoſe they have drawn over it, and ſeeming to ſhuffle the cards indiſcriminately, you cut them again at the long card; and ſhow one of them his card. You then ſhuffle and cut again in the ſame manner, and ſhow another per-

* See Vol. I. p. 42.

† There is frequently exhibited another experiment, ſimilar to this, which is by making a perſon draw the long card, then giving him the pack, you tell him to place his card where he pleaſes, and ſhuffle them, and you will then name his card, or cut the pack where it is. You may alſo tell him to put the pack in his pocket, and you will draw the card, which you may eaſily do by the touch.

ſon his card, and ſo on: remembering that the card drawn off by the laſt perſon is the firſt next the long card; and ſo of the others.

This recreation may be performed without the long card, in the following manner. Let a perſon draw any card whatever, and replace it in the pack: you then make the paſs, and bring that card to the top of the pack, and ſhuffle them without loſing ſight of that card. You then offer that card to a ſecond perſon, that he may draw it, and put it in the middle of the pack. You make the paſs and ſhuffle the cards a ſecond time, in the ſame manner, and offer the card to a third perſon, and ſo again to a fourth or fifth, as is more fully explained further on.

RECREATION CXXXIV.

The four confederate cards.

YOU let a perſon draw any four cards from the pack, and tell him to think on one of them. When he returns you the four cards you dextrouſly place two of them under the pack and two on the top. Under thoſe at the bottom you place four cards of any ſort, and then taking eight or ten from the bottom cards, you ſpread them on the table, and aſk the perſon if the card he fixed on be among them. If he ſay *no*, you are ſure it is one of the two cards on the top. You then paſs thoſe two cards to the bottom, and drawing off the loweſt of them, you aſk if that is not his card. If he again ſay *no*, you take that card up, and bid him draw his card from the bottom of the pack.

If the perſon ſay his card is among thoſe you firſt drew from the bottom, you muſt dextrouſly take up the four cards that you put under them, and placing thoſe on the top, let the other two be the bottom cards of the pack, which you are to draw in the manner before deſcribed.

RECRE-

RECREATION CXXXV.

The numerical card.

LET the long card be the ſixteenth in a pack of piquet cards. Take ten or twelve cards from the top of the pack, and ſpreading them on the table deſire a perſon to think of any one of them, and to obſerve the number it is from the firſt card. Make the paſs at the long card, which will then be at the bottom. Then aſk the party the number his card was at, and counting to yourſelf from that number to 16, turning the cards up one by one, from the bottom. Then ſtop at the ſeventeenth card, and aſk the perſon if he has ſeen his card, when he will ſay *no*. You then aſk him how many more cards you ſhall draw before his card appears; and when he has named the number, you draw the card aſide with your finger, and turn up the number of cards he propoſed, and then throw down the card he fixed on.

RECREATION CXXXVI.

Divination by the ſword.

AFTER a card has been drawn you place it under the long card, and by ſhuffling them dextrouſly you bring it to the top of the pack. Then lay, or throw, the pack on the ground, obſerving where the top card lies A handkerchief is then bound over your eyes, in ſuch manner however that you may ſee the ground, which may be eaſily done. A ſword is then put into your hand, with which you touch ſeveral of the cards, ſeemingly in great doubt, but never loſing ſight of the top card, in which at laſt you fix the point of the ſword, and preſent it to him who drew it. Two or three cards may be diſcovered in the ſame manner, that is, by placing them under the long card, and then bringing them to the top of the pack.

RECRE-

RECREATION CXXXVII.

The card thought on per force.

YOU ſpread part of a pack of cards before a perſon, in ſuch manner that one of the picture cards only is completely viſible. You then tell him to think on one of thoſe cards, obſerving attentively if he fix his eye on the picture card. When he ſays he has determined, you ſhuffle the cards, and turning them up, one by one, you tell him that is his card.

If he does not appear to fix his eye on the pictured card, or if he ſpread the cards in order to fix on another, you tell him to draw the card he chooſes, and then by placing it under the long card you perform ſome other recreation. It is eaſy to conceive that this recreation may fail, and that it ſhould not be attempted with thoſe who are converſant with deceptions of this ſort.

RECREATION CXXXVIII.

The tranſmutable cards.

YOU muſt have in the pack two cards of the ſame ſort, ſuppoſe the king of ſpades. One of theſe is to be placed next the bottom card, which may be the ſeven of hearts, or any other card. The other is to be placed at top. You then ſhuffle the cards, without diſplacing thoſe three cards, and ſhow a perſon that the bottom card is the ſeven of hearts Then drawing that card privately aſide with your finger, which you have wetted for that purpoſe, you take the king of ſpades from the bottom, which the perſon ſuppoſes to be the ſeven of hearts, and lay it on the table, telling him to cover it with his hand. You then ſhuffle the cards again, without diſplacing the firſt and laſt card, and paſſing the other king of ſpades at the top to the bottom, you ſhow it to another perſon. You then draw that privately away, and taking the bottom card, which will then be the ſeven of hearts, you lay that on the

the table, and tell the second person, who believes it to be the king of spades, to cover it with his hand.

You then command the seven of hearts, which is supposed to be under the hand of the first person, to change into the king of spades; and the king of spades, which is supposed to be under the hand of the second person, to change into the seven of hearts; and when the two parties take their hands off, and turn up the cards, they will see, to their no small astonishment, after having so carefully observed the bottom cards, that your commands are punctually obeyed.

RECREATION CXXXIX.

The three magical parties.

YOU are to offer the long card to any one, that he may draw it, and place it again in any part of the pack he thinks proper. You then make the pass, and bring that card to the top of the pack. You next divide the pack into three heaps, observing to put the long card in the middle heap, as that is most commonly chose. You then demand of the person which of the heaps the card he drew shall be in. If he reply in the middle parcel, you immediately show him the card. But if he say in either of the others, you take all the cards in your hand, placing the parcel he has named over the other two, observing to put your little finger between that and the middle heap, at the top of which is the card he drew. You then ask at what number in that heap he will have his card appear. If he say, for example, the sixth card, you tell down five cards from the top of the pack, and then dextrously making the pass, you bring the long card to the top, and tell it down as the sixth.

RECREATION CXL.

The inverted cards.

PREPARE a pack of cards, by cutting one end of them about one-tenth of an inch narrower than the other; then offer the pack to any one that he may draw a card;

a card; place the pack on the table, and obſerve carefully if he turn the card while he is looking at it: if he do not, when you take the pack from the table, you offer the other end of it for him to inſert that card; but if he turn the card, you then offer him the ſame end of the pack. You afterwards offer the cards to a ſecond or third perſon, for them to draw and replace a card in the ſame manner. You then let any one ſhuffle the cards and taking them again in your own hand, as you turn them up one by one, you eaſily perceive by the touch which thoſe cards are that have been inverted, and laying the firſt of them down on the table, you aſk the perſon if that card be his, if he ſay *no*, you aſk the ſame of the ſecond perſon, and if he ſay *no*, you tell the third perſon it is his card; and ſo of the ſecond and third cards. You ſhould lay the pack on the table after each perſon has drawn his card, and turn it dextrouſly in taking it up, when it is to be turned, that the experiment may not appear to depend on the cards being inverted.

RECREATION CXLI.

The card diſcovered by the touch or ſmell.

YOU offer the long card, or any other that you know, and as the perſon who has drawn it holds it in his hand, you pretend to feel the pips or figure on the under ſide by your fore finger; or you ſagaciouſly ſmell to it, and then pronounce what card it is.

If it be the long card, you may give the pack to the perſon who drew it, and leave him at liberty either to replace it, or not. Then taking the pack, you feel immediately whether it be there or not, and ſhuffling the cards in a careleſs manner, without looking at them, you pronounce accordingly.

RECREATION CXLII.

The incomprehenſible tranſpoſition.

TAKE a card, the ſame as your long card, and rolling it up very cloſe, put it in an egg, by making a hole

hole as ſmall as poſſible, and which you are to fill up carefully with white wax. You then offer the long to be drawn, and when it is replaced in the pack you ſhuffle the cards ſeveral times, giving the egg to the perſon who drew the card, and while he is breaking it, you privately withdraw the long card, that it may appear, upon examining the cards, to have gone from the pack into the egg. This Recreation may be rendered more ſurpriſing by having ſeveral eggs, in each of which is placed a card of the ſame ſort, and then giving the perſon the liberty to chooſe which egg he thinks fit.

This deception may be ſtill further diverſified, by having, as moſt public performers have, a confederate, who is previouſly to know the egg in which the card is placed; for you may then break the other eggs, and ſhow that the only one that contains a card is that in which you directed it to be.

RECREATION CXLIII.

The card in the pocket-book.

THIS Recreation is to be performed by a confederate, who is previouſly to know the card you have taken from the pack and put in your pocket book. You then preſent the pack to your confederate, and deſire him to fix on a card, (which we will ſuppoſe to be the queen of diamonds) and then place the pack on the table. You then aſk him the name of the card, and when he ſays the queen of diamonds, you aſk him if he be not miſtaken, and if he be ſure that card is in the pack: when he replies in the affirmative, you ſay, it might be there when you looked over the cards, but I believe it is now in my pocket: then deſire a third perſon to put his hand in your pocket, and take out your book, and when it is opened the card will appear.

Experiments of this kind appear as wonderful to thoſe who have no idea of a confederacy, as they do ſimple and trifling to thoſe that are in the ſecret.

RECREATION

RECREATION CXLIV.

To tell the card that a perſon has only once touched with his finger.

THIS Recreation alſo is to be performed by confederacy. You previouſly agree with your confederate on certain ſigns, by which he is to denote the ſuit, and the particular card of each ſuit; as thus: if he touch the firſt button of his coat, it ſignifies an ace; if the ſecond, a king, &c. and then again if he take out his handkerchief, it denotes the ſuit to be hearts; if he take ſnuff, diamonds, &c. Theſe preliminaries being ſettled, you give the pack to a perſon who is near your confederate, and tell him to ſeparate any one card from the reſt, while you are abſent, and draw his finger once over it. He is then to return you the pack, and while you are ſhuffling the cards, you carefully note the ſignals made by your confederate. Then turning the cards over one by one, you directly fix on the card he touched.

RECREATION CXLV.

To name ſeveral cards that two perſons have drawn from the pack.

DIVIDE a piquet pack of cards into two parts by a long card. Let the firſt part contain a quint to a king in clubs and ſpades, the four eights, the ten of diamonds, and ten of hearts; and let the other part contain the two quart majors in hearts and diamonds, the four ſevens and the four nines.*

Then ſhuffle the cards, but obſerve not to diſplace any of thoſe cards of the laſt part which are under the long card. You then cut at that card, and leave the pack in two parts. Next, preſent the firſt of thoſe parts to a perſon, and tell him to draw two or three cards, and place the remainder on the table. You preſent

* The cards may be divided in any other manner that is eaſy to be remembered.

ſent the ſecond parcel in like manner to another. Then having dextrouſly placed the cards drawn by the firſt perſon in the ſecond parcel, and thoſe drawn by the ſecond perſon in the firſt parcel, you ſhuffle the cards, obſerving to diſplace none but the upper cards. Then ſpreading the cards on the table, you name thoſe that each perſon drew; which you will very eaſily do, by obſerving the cards that are changed in each parcel.

RECREATION CXLVI.

The two convertible aces.

ON the ace of ſpades fix with ſoap, a heart, and on the ace of hearts a ſpade, in ſuch manner that they will eaſily ſlip off.

Show theſe two aces to the company; then taking the ace of ſpades you deſire a perſon to put his foot upon it, and as you place it on the ground, draw away the ſpade. In like manner you place the ſeeming ace of hearts under the foot of another perſon. You then command the two cards to change their places; and that they obey your command, the two perſons, on taking up their cards, will have ocular demonſtration.*

RECREATION CXLVII.

The fifteen thouſand livres.

YOU muſt be prepared with two cards, like thoſe repreſented by Plate XXXIV. Fig. 3. and with a common ace and five of diamonds.

* A deception ſimilar to this is ſometimes practiſed with one card, ſuppoſe the ace of ſpades, over which a heart is paſted ſlightly. After ſhowing a perſon the card you let him hold one end of it, and you hold the other, and while you amuſe him with diſcourſe you ſlide off the heart. Then laying the card on the table you bid him cover it with his hand. You then knock under the table, and command the heart to turn into the ace of ſpades. By deceptions like theſe people of little experience and much conceit are frequently deprived of their money and rendered ridiculous.

The five of diamonds and the two prepared cards are to be disposed as in Fig. 4. and holding them in your hand, you say. "A certain Frenchman left fifteen thousand livres, which are represented by these three cards, to his three sons. The two youngest agreed to leave their 5000, each of them in the hands of the elder, that he might improve it." While you are telling this story you lay the 5 on the table, and put the ace in its place, and at the same time artfully change the position of the other two cards, that the 3 cards may appear as in Fig. 5. You then resume your discourse. "The eldest brother, instead of improving the money, lost it all by gaming, except three thousand livres, as you here see." You then lay the ace on the table, and taking up the 5, continue your story: "The eldest, sorry for having lost the money, went to the East-Indies, with these 3000, and brought back 15000." You then shew the cards in the same position as at first, in Fig. 3.

To render this deception agreeable, it must be performed with dexterity, and should not be repeated, but the cards immediately put in the pocket; and you should have five common cards in your pocket, ready to show, if any one should desire to see them.

Another recreation of this sort may be performed with fives and threes, as in Fig. 6, 7, and 8.

RECREATION CXLVIII.

The card discovered under the handkerchief.

LET a person draw any card from the rest, and put it in the middle of the pack. You make the pass at that place, and the card will consequently be at top. Then placing the pack on the table, cover it with a handkerchief, and putting your hand under it, take off the top card, and after seeming to search among the cards for some time, draw it out.

This recreation may be performed by putting the cards in another person's pocket, after the pass is made.

Several

Several cards may alſo be drawn and placed together in the middle of the pack, and the paſs then made.

RECREATION CXLIX.

To change the cards that ſeveral perſons have drawn from the pack.

ON the top of the pack put any card you pleaſe, ſuppoſe the queen of clubs. Make the paſs, and bring that card to the middle of the pack, and offer it a perſon to draw. Then, by cutting the cards, bring the queen again to the middle of the pack. Make the paſs a ſecond time, and bring it to the top, and ſhuffle the cards without diſplacing thoſe on the top. Make the paſs a third time, and bring it to the middle of the pack, and offer it to a ſecond perſon to draw; who muſt be at a proper diſtance from the firſt perſon, that he may not perceive it is the ſame card. After the like manner did five perſons draw the ſame card.

Shuffle the pack, without loſing ſight of the queen of clubs, and laying down four other cards with the queen, aſk each perſon if he ſees his card there. They will all reply *yes*, as they all drew the queen of clubs.

Place four of thoſe cards to the pack, and drawing the queen privately away; you approach the firſt perſon, and ſhowing him that card, ſo that the others cannot ſee it, and aſk if that be his card. Then putting it on the top of the pack blow on it, or give it a ſtroke with your hand, and ſhew it in the ſame manner to the ſecond perſon; and ſo of the reſt.

RECREATION CL.

The four inſeparable kings.

TAKE the four kings, and behind the laſt of them place two other cards, ſo that they may not be ſeen. Then ſpread open the four kings to the company, and put the ſix cards at the bottom of the pack. Draw one of the kings, and put him at the top of the pack. Draw one of the two cards at the bottom and put it to-

wards the middle. Draw the other, and put it at ſome diſtance from the laſt, and then ſhow that there remains a king at bottom. Then let any one cut the cards, and as there remained three kings at bottom, they will then be altogether in the middle of the pack.

RECREATION CLI.

To tell the number of cards by their weight.

TAKE a parcel of cards, ſuppoſe 40, among which inſert two long cards; let the firſt be, for example, the 15th, and the other the 26th from the top. Seem to ſhuffle the cards, and then cutting them at the firſt long card, poiſe thoſe you have cut off in your left hand, and ſay, "there ſhould be here fifteen cards." Cut them again at the ſecond long card, and ſay, "there are here only eleven cards." Then poiſing the remainder, you ſay, "here are fourteen cards."

RECREATION CLII.

To diſcover the card that is drawn by the throw of a die.

PREPARE a pack of cards, in which ſix different cards are contained ſix times; that is in which there are only ſix ſorts of cards. Diſpoſe theſe cards in ſuch manner that each of the ſix different cards ſhall follow each other, and let the laſt of each ſuit be a long card. The cards being thus diſpoſed, it follows, that if you divide them into ſix parcels, by cutting at each of the long cards, thoſe parcels will all conſiſt of ſimilar cards.

Let a perſon draw a card from the pack, and let him replace it in the parcel from whence it was drawn, by dextrouſly offering that part. Cut the cards ſeveral times, ſo that a long card may be always at bottom. Divide the cards in this manner into ſix heaps, and giving a die to the perſon who drew the card, tell him that the point he throws ſhall indicate the parcel in which is the card he drew; then take up that parcel and ſhow him the card.

You

You ſhould put the cards in your pocket immediately after performing this Recreation, and have another pack, ready to ſhow, if any one ſhould aſk to ſee the cards.

RECREATION CLIII.

To ſeparate the two colours of a pack of cards by one cut.

THE pack muſt be prepared in the ſame manner as in the 140th Recreation; that is, all the cards of one colour muſt be cut ſomething narrower at one end than the other. You ſhow the cards and give them to any one that he may ſhuffle them, then holding them between your hands, one hand being at each extremity, with one motion you ſeparate the hearts and diamonds from the ſpades and clubs.

This Recreation is eaſy and pleaſant to perform, but ſhould not be repeated; unleſs you have another pack of cards which you can adroitly ſubſtitute in the place of the former, and with them you may ſeparate the pictured cards from the others, they being prepared for that purpoſe; which will afford a freſh ſurpriſe. You may alſo write on a number of blank cards certain letters or words that form a queſtion, and on others the anſwer. Several other recreations may likewiſe be performed by the ſame method.

RECREATION CLIV.

The metamorphoſed cards.

In the middle of a pack place a card that is ſomething wider than the reſt which we will ſuppoſe to be the knave of ſpades, under which place the ſeven of diamonds and under that the ten of clubs. On the top of the pack put cards ſimilar to theſe, and others on which are painted different objects in the manner following:

First card	A bird
2	A ſeven of diamonds
3	A flower
4	Another ſeven of diamonds
5	A bird
6	Ten of clubs
7	A flower
8	Another ten of clubs.

Then ſeven or eight indifferent cards; the knave of ſpades, which is the wide card; the ſeven of diamonds; the ten of clubs; and the reſt any indifferent cards.

Two perſons are then to draw the two cards that are under the wide card, which are the ſeven of diamonds and the ten of clubs. You then take the pack in your left hand, and open it at the wide card, as you open a book, and tell him who drew the ſeven of diamonds to place it in that opening. You then blow on the cards, and without cloſing them you inſtantly bring the card up which is at top, and on which a bird is painted, over that ſeven of diamonds*. You then bid the perſon look at his card, and when he has remarked the change, to place it where it was before. Then blow on the cards a ſecond time, and bringing the ſeven of diamonds which is at the top of the pack, to the opening, you bid him look at his card again, when he will ſee it is that he drew. You may do the ſame with all the other painted cards, either with the ſame perſon or with him who drew the ten of clubs.

The whole artifice in this Recreation conſiſts in bringing the card at the top of the pack to the opening in the middle, by the wet finger, which requires no great practice. You muſt obſerve not to let the pack go out of your hands while you are performing this recreation.

RECRE-

* To do this dextrouſly you muſt wet the middle finger of your left hand, with which you are to bring the card to the middle of the pack.

RECREATION. CLV.

The cards in the opera glaſs.

PROVIDE an opera glaſs about two inches and a half long, the tube of which is to be ivory, and ſo thin that the light may paſs through it. In this tube place a lens of two inches and a quarter focus, ſo that a card of about three quarters of an inch long may appear of the ſize of a common card. At the bottom of the tube there is to be a circle of black paſteboard to which muſt be faſtened a ſmall card with figures on both ſides, by two threads of ſilk, in ſuch manner that by turning the tube either ſide of the card may be viſible.

You then offer two cards in a pack to two perſons, which they are to draw, and that are the ſame as thoſe in the glaſs. After which you ſhow each of them the card he has drawn, in the glaſs, by turning it to the proper poſition.

The better to induce the parties to draw the two cards, place them firſt on the top of the pack, and then, by making the paſs, bring them to the middle. When you can make the paſs in a dextrous manner, it is preferable, on many occaſions, to the long card, which obliges you to change the pack frequently; for otherwiſe it would be obſerved that the ſame card is always drawn, and doubtleſs occaſion ſuſpicion.

RECREATION CLVI.

The magic ring.

MAKE a ring large enough to go on the ſecond or third finger, (Pl. XXXIV. Fig. 9.) in which let there be ſet a large tranſparent ſtone, to the bottom of which muſt be fixed a ſmall piece of black ſilk, that may be either drawn aſide or expanded by turning the ſtone round. Under the ſilk is to be the figure of a ſmall card.

Then make a perſon draw the ſame ſort of card as that at the bottom of the ring, and tell him to burn it in

in the candle. Having firſt ſhown him the ring, you take part of the burnt card, and reducing it to powder, you rub the ſtone with it, and at the ſame time turn it artfully about, ſo that the ſmall card at bottom may come in view.

RECREATION CLVII.

The card in the mirror.

PROVIDE a mirror, either round, as A, (Plate XXXIV. Figure 10) or oval, the frame of which muſt be at leaſt as wide as a card. The glaſs in the middle muſt be made to move in the two grooves CD and EF, and ſo much of the quickſilver muſt be ſcraped off at B, as is equal to the ſize of a common card. You will obſerve that the glaſs muſt likewiſe be wider than the diſtance between the frame, by at leaſt the width of a card.

Then paſte over the part where the quickſilver is rubbed off, a piece of paſteboard, on which is a card, that muſt exactly fit the ſpace, which muſt at firſt be placed behind the frame.

This mirror muſt be placed againſt a partition, through which is to go two ſtrings, by which an aſſiſtant in the adjoining room can eaſily move the glaſs in the grooves, and conſequently make the card appear or diſappear at pleaſure*.

Matters being thus prepared, you contrive to make a perſon draw the ſame ſort of card with that fixed to the mirror, and place it in the middle of the pack: you then make the paſs, and bring it to the bottom; you then direct the perſon to look for his card in the mirror, when the confederate behind the partition is to draw it ſlowly forward, and it will appear as if placed between

* This Recreation may be performed without an aſſiſtant, if a table be placed againſt the partition, and the ſtring from the glaſs be made to paſs through a leg of it and communicate with a ſmall trigger, which you may eaſily puſh down with your foot, and at the ſame time be wiping the glaſs with your handkerchief, that the card may appear the more conſpicuous. It may alſo be diverſified by having the figure of a head, ſuppoſe that of ſome abſent friend, in the place of the card.

between the glaſs and the quickſilver. While the glaſs is drawing forward you ſlide off the card from the bottom of the pack, and convey it away.

The card fixed to the mirror may eaſily be changed each time the experiment is performed. This recreation may be alſo made with the print that has a glaſs before it, and a frame of ſufficient width; by making a ſlit in the frame through which the card is to paſs; but the effect will not be ſo ſtriking as in the mirror.

RECREATION CLVIII.

The marvellous vaſe.

PLACE a vaſe of wood or paſteboard AB, (Plate XXXIV. Fig. 11.) on a bracket L, fixed to the partition M. Let the inſide of this vaſe be divided into five parts, *c*, *d*, *e*, *f*, *g*, and let the diviſions *c* and *d* be wide enough to admit a pack of cards, and thoſe of *e*, *f*, *g*, one card only.

Fix a thread of ſilk at the point H, the other end of which paſſing down the diviſion *d*, and over the pulley I, runs along the bracket L, and goes out behind the partition M.

Take three cards from a piquet pack, and place one of them in each of the diviſions *e*, *f*, *g*, making the ſilk thread or line go under each of them. In the diviſion *c*, put the pack of cards from which you have taken the three cards that are in the other diviſion.

Then take another pack of cards, at the top of which are to be three cards of the ſame ſort with thoſe in the three ſmall diviſions, and making the paſs, bring them to the middle of the pack, and let them be drawn by three different perſons. Then give them all the cards to ſhuffle, after which place the pack in the diviſion *d*, and tell the parties they ſhall ſee the three cards they drew come, at their command, ſeparately out of the vaſe.

An aſſiſtant behind the partition then drawing the line, with a gentle and equal motion, the three cards will gradually riſe out of the vaſe. Then take the cards

cards out of the diviſion *c*, and ſhow that thoſe three cards are gone from the pack.

The vaſe muſt be placed ſo high that the inſide cannot be ſeen by the company.

You may perform this recreation alſo without an aſſiſtant, by fixing a weight to the end of the ſilk line, which is to be placed on a ſupport, and let down at pleaſure, by means of a ſpring in the partition.

RECREATION CLIX.

The divinating perſpective glaſs.

LET a ſmall perſpective glaſs be made, that is wide enough at the end where the object-glaſs is placed, to hold a table ſimilar to the following.

1.131	10..132	19.133
2.231	11. 232	20.233
3.331	12..332	21.333
4.121	13..122	22.123
5.221	14..222	23.223
6.321	15..322	24.323
7.111	16..112	25.113
8.211	17..212	26.213
9.311	18..312	27.313

Take a pack of cards that conſiſts of 27 only, and giving them to a perſon, deſire him to fix on any one, then ſhuffle them and give the pack to you. Place the twenty-ſeven cards in three heaps, by laying down one alternately on each heap, but before you lay each card down ſhow it to the perſon without ſeeing it yourſelf; and when the three heaps are finiſhed, aſk him at what number, from 1 to 27, he will have his card appear, and in which heap it then is. Then look at the heap through the glaſs, and if the firſt of the three numbers which ſtands againſt that number it is to appear at be

1,

1, put that heap at top: if the number be 2, put it in the middle; and if it be 3, put it at bottom. Then divide the cards into three heaps, in the same manner, a second and a third time, and his card will then be at the number he chose.

For example. Suppose he desire that his card shall be the 20th from the top, and the first time of making the heaps he say it is in the third heap; you then look at the table in the perspective, holding it at the same time over that heap, and you see that the first figure is 2, you therefore put that heap in the middle of the pack. The second and the third times you in like manner put the heap in which he says it is, at the bottom, the number each time being 3. Then looking at the pack with your glass, as if to discover which the card was, you lay the cards down one by one, and the twentieth card will be that he fixed on.

You may show the person his card in the same manner, without asking him at what number it shall appear, by fixing on any number yourself. You may also perform this Recreation with the magnetical dial before described by making the hand point to any number, from 1 to 27, at which you intend the card shall be found.

The foregoing recreations with the cards will be found sufficient to explain all others of a similar nature, that have or may be made, the number of which is very great. To perform these we have described requires no great practice; the two principal points are, the making the pass in a dextrous manner, and a certain address by which you influence a person to draw the card you present.

Those recreations that are performed by the long card are, in general, the most easy, but they are confined to a pack of cards that is ready prepared; whereas, those that depend on making the pass, may be performed with any pack that is offered.

RECRE-

RECREATION CLX.

The burnt writing reſtored.

COVER the outſide of a ſmall memorandom book with black paper, and in one of its inſide covers make a flap, to open ſecretly, and obſerve there muſt be nothing over the flap but the black paper that covers the book.

Mix ſoot with black or brown ſoap, with which rub the ſide of the black paper next the flap; then wipe it quite clean, ſo that a white paper preſſed againſt it will not receive any mark.

Provide a black lead pencil that will not mark without preſſing hard on the paper. Have likewiſe a ſmall box, about the ſize of the memorandum-book, and that opens on both ſides, but on one of them by a private method. Give a perſon the pencil, and a ſlip of thin paper, on which he is to write what he thinks proper: you preſent him the memorandum-book at the ſame time, that he may not write on the bare board. You tell him to keep what he writes to himſelf, and direct him to burn it on an iron plate laid on a chafing-diſh of coals, and give you the aſhes. You then go into another room to fetch your magic box, before deſcribed, and take with you the memorandum-book.

Having previouſly placed a paper under the flap in the cover of the book, when he preſſes hard with the pencil, to write on his paper, every ſtroke, by means of the ſtuff rubbed on the black paper, will appear on that under the flap. You therefore take it out, and put it into one ſide of the box.

You then return to the other room, and taking a ſlip of blank paper, you put it into the other ſide of the box, ſtrewing the aſhes of the burnt paper over it. Then ſhaking the box for a few moments, and at the ſame time turning it dextrouſly over, you open the other ſide, and ſhew the perſon the paper you firſt put in, the writing on which he will readily acknowledge to be his.

If there be a preſs or cupboard that communicates with the next room, as in the 121ſt Recreation, you need only put the book in the preſs, and your aſſiſtant will open it and put the paper in the box, which you preſently after take out, and perform the reſt of the recreation as before.

There may likewiſe be a flap in the other cover of the book, and you may rub the paper againſt that with red lead. In this caſe you give the perſon the choice of writing either with a red or black pencil; and preſent him the proper ſide of the book accordingly.

RECREATION CLXI.

The opaque box rendered tranſparent.

MAKE a box of three or four inches long, and two or three wide, and have a ſort of perſpective glaſs, the bottom of which is of the ſame ſize with the box, and ſlides out, that you may privately place a paper on it. The ſides of this perſpective are to be of glaſs, covered on the inſide with fine paper.

Let a perſon write on a ſlip of paper, putting your memorandum-book under it as in the laſt Recreation. Then give him the little box, and let him put what he has wrote into it. In the mean time you put the memorandum-book into the preſs, where the perſpective is already placed. Your aſſiſtant then takes the paper out of the book, and puts it at the bottom of the perſpective; which you preſently take out of the preſs, and direct the perſon to put the little box, that contains his paper, under it. You then look in at the top of the perſpective, and feigning to ſee through the top of the box, you read what is wrote on the paper at the bottom of the perſpective.

With this perſpective box you may perform another recreation, which is, by having in a bag twelve or more ivory counters, numbered, which you ſhow to the company, that they may ſee all the numbers are different. You tell a perſon to draw any one of them, and keep it cloſe in his hand. You then put

the bag in the preſs, when your aſſiſtant examines the counters, and ſees which is wanting, and puts another of the ſame number at the bottom of the perſpective, which you then take out; and placing the perſon's hand cloſe to it, look in at the top, and pretending to ſee through his hand, you name the number on the counter in it.

RECREATION CLXII.

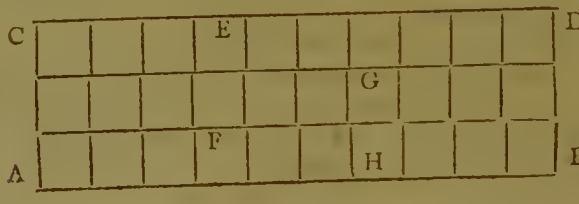
The tranſpoſable pieces.

TAKE two guineas and two ſhillings, and grind part of them away, on one ſide only, ſo that they may be but half of the common thickneſs; and obſerve that they muſt be quite thin at the edge; then rivet a guinea and a ſhilling together. Lay one of theſe double pieces with the ſhilling upwards, on the palm of your hand, at the bottom of your three firſt fingers; and lay the other piece, with the guinea upward, in like manner, in the other hand. Let the company take notice in which hand is the guinea, and in which the ſhilling. Then as you ſhut your hands, you naturally turn the pieces over, and when you open them again, the ſhilling and the guinea will appear to have changed their places.

RECREATION CLXIII.

The geometric money.

DRAW on a paſteboard the following rectangle ABCD, whoſe ſide AC is three inches, and AB ten inches.

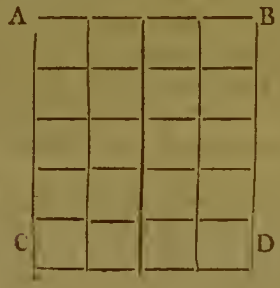


Divide

Divide the longeſt ſide into ten equal parts, and the ſhorteſt into three equal parts, and draw the perpendicular lines, as in the figure, which will divide it into thirty equal ſquares.

From A to D draw the diagonal AD, and cut the figure, by that line, into two equal triangles, and cut thoſe triangles into two parts, in the direction of the lines EF and GH. You will then have two triangles, and two four-ſided irregular figures, which you are to place together, in the manner they ſtood at firſt, and in each ſquare you are to draw the figure of a piece of money; obſerving to make thoſe in the ſquares, through which the line AD paſſes, ſomething imperfect.

As the pieces ſtand together in the foregoing figure, you will count thirty pieces of money only; but if the two triangles and the two irregular figures be joined together as in the following figures, there will be thirty-two pieces.





RECREATION CLXIV.

The penetrative guinea.

PROVIDE a round tin box, of the ſize of a large ſnuff-box, and in this place eight other boxes, which will go eaſily into each other, and let the leaſt of them be of a ſize to hold a guinea. Each of theſe boxes ſhould ſhut with a hinge, and to the leaſt of them there

muſt be a ſmall lock, that is faſtened with a ſpring, but cannot be opened without a key: and obſerve that all theſe boxes muſt ſhut ſo freely, that they may be all cloſed at once. Place theſe boxes in each other, with their tops open, in the drawer of the table on which you may make your experiments; or if you pleaſe, in your pocket, in ſuch manner that they cannot be diſplaced.

Then aſk a perſon to lend you a new guinea, and deſire him to mark it, that it may not be changed. You take this piece in one hand, and in the other you have another of the ſame appearance, and putting your hand into the drawer you ſlip the piece that is marked in the leaſt box, and ſhutting them all at once, you take them out. Then ſhowing the piece you have in your hand, and which the company ſuppoſe to be the ſame that was marked, you pretend to made it paſs through the box and dextrouſly convey it away.

You then preſent the box, for the ſpectators do not yet know there are more than one, to any perſon in company, who, when he opens it, finds another, and another, till he comes to the laſt, but that he cannot open without the key, which you then give him, and retiring to a diſtant part of the room, you tell him to take out the guinea himſelf, and ſee if it be that he marked.

This recreation may be made more ſurpriſing, by putting the key into the ſnuff-box of one of the company, which you may do by aſking him for a pinch of his ſnuff, and at the ſame time conceal the key, which muſt be very ſmall, among the ſnuff: and when the perſon who is to open the box aſks for the key, you tell him that one of the company has it in his ſnuff-box. This part of the recreation may likewiſe be performed by means of a confederate.

RECRE-

RECREATION CLXV.

The reſuſcitated flower.

PROVIDE a ſmall tin mortar, that is double, whoſe bottom turns round on an axis, by means of a ſpring. There muſt be a hollow ſpace under the falſe bottom. To the under ſide of the bottom faſten, by a thread of fine ſilk, a flower with its ſtalk and leaves.

Then take a flower that exactly reſembles the other, and plucking it from the ſtalk, and all the leaves from each other, put them into the mortar, and pound them with a ſmall peſtle; after which you ſhow the mortar to the company, that they may ſee the parts that are all bruiſed.

Then taking the mortar up in your hands, you hold it over the flame of a lamp or candle, by whoſe warmth the flower is ſuppoſed to be reſtored; and at the ſame time preſſing the ſpring, the bottom will turn round, the bruiſed parts deſcend into the ſpace under the bottom, and the whole flower will be at top; you then put your hand into the mortar, and eaſily breaking the ſilk thread, which may be very ſhort as well as fine, you take the flower out and preſent it to the company.

There is an experiment ſimilar to this, in which a live bird is concealed at the bottom of the mortar, and one that is dead is pounded in it; after which, by the motion of the bottom, the live bird is ſet at liberty. But ſurely the pounding a bird in a mortar, though it be dead, muſt produce, in perſons of any delicacy, more diſguſt than recreation.

AN ARTIFICIAL MEMORY.

THE reader muſt have obſerved, that to perform ſeveral of the recreations in this book, it is neceſſary to have a good memory; but as that is a gift every one has not from nature, many methods have been contrived to ſupply that defect by art; the moſt material of which we ſhall here deſcribe.

An

An artificial memory reſpects either figures or words: for the former let the five vowels *a*, *e*, *i*, *o*, *u*, repreſent the firſt five digits; the dipthongs that begin with the firſt four vowels, as *au*, *ea*, *ie*, *ou*, repreſent the remaining four digits, and let *y* ſtand for an o, or cypher. Let the firſt ten conſonants alſo ſtand for the nine digits and the cypher; as in the following table.

a	*e*	*i*	*o*	*u*	*au*	*ea*	*ie*	*ou*	*y*
1	2	3	4	5	6	7	8	9	0
b	*c*	*d*	*f*	*g*	*h*	*k*	*l*	*m*	*n*

Then to repreſent any number let the firſt letter be a vowel or dipthong, the ſecond a conſonant, the third a vowel the fourth a conſonant, &c. Thus for the number 1763, you write or remember the word *akaud*. If there are ſeveral ſums to be retained, you place the words in forms of verſes, which will make them more pleaſing to repeat and more eaſy to remember: for example, if you would remember the dates of the acceſſion of the family of Stuart to the crown of England; the powder plot; the decapitation of Charles I. the Reſtoration; the Revolution; the Union of England and Scotland; the acceſſion of the Houſe of Hanover; and the laſt rebellion, which were in 1603, 1605, 1649, 1660, 1689, 1707, 1714, and 1746, you write as follows, for you are to obſerve that in this, and in ſimilar caſes, where the firſt figure is always the ſame, it is unneceſſary to write it after the firſt time.

Ahyd hyg hom haun
hiem kyk kaf koh.

This method is rendered in ſome inſtances ſtill more eaſy by adding parts of words to dates: thus to remember the date of the acceſſion of the monarchs from James I. to the preſent king, you may write as follows, omitting the letter that would ſtand for one thouſand.

Jam*hyd* Char*heg* Char*hom* Jam*hieg*
Will*hiem* An*kyc* Geor*kaf* Se*ckek* Thi*kaun*

When

When ſeveral cyphers come together, inſtead of repeating *y* or *n*, you may write *y* or *n*, 2, 3, &c. Thus for 3400 *ify2*, and for 256000 write *ehun3*.

To remember any number of words, ſelect the initial letters of thoſe words, and to the firſt add *a* if it begin with a conſonant, or *b* if it begin with a vowel. In like manner add *e* or *c* to the ſecond initial letter; to the third add *i* or *d*; to the fourth *o* or *f*; and to the fifth *u* or *g*. So that of the five initials you make five ſyllables, which are joined together in one word. Then of the next five initials you make in the ſame manner. another word, and of every two words you make a verſe. For example, ſuppoſe you would remember the names of all the kings ſince the Conqueſt, in the order in which they reigned, you then write as follows.

Wawchiſohu	*Rajehiefeg*
Ebrehihohu	*Ebecrihohu*
Ebmeedjocu	*Cajewiafgu Gage*

Or if you would remember the letters that begin any number of verſes, ſuppoſe the twenty-firſt lines of Pope's Eſſay on Man, you write as follows.

Abtelitoeg	*Abacodtotu*
Taocedaf lu	*Baſewioffu.*

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RECREATION I. p. 21

The animated feather.

A feather being brought near an excited tube is first attracted by it and then repelled, and the tube cannot be brought close to the feather, till it has touched some other body.

RECREATION II. p. 22

The self-raising pyramid.

A large bundle of threads being suspended from the electric branch, (Plate III. Fig. 3.) will rise up in form of a pyramid, and continue so long as the wheel is turned, but when

when that ceaſes the threads will reſume their firſt poſition.

RECREATION III. p. 22

The magical dance.

Three bells are ſuſpended from the electric branch, and between them hang two braſs knobs. The bells being electrified will attract the clappers, and be ſtruck by them, and the ringing will continue as long as the machine is in motion. This is the muſic for the dance. A plate is then ſuſpended from the branch, and on a metal ſtand, placed under it, are put the figures of men, which being attracted by the plate will be in continual motion. This Recreation may be ſuſpended or renewed at pleaſure.

RECREATION IV. p. 23

The artificial ſpider.

The body of this ſpider is of cork, and its legs of linen thread. When it is held, by a fine line of ſilk, between the electric branch and an excited ſtick of wax, it will appear to be animated, continually jumping from one to the other.

RECREATION V. p. 24

The marvellous fountain.

A veſſel of water, in which a ſyphon is placed, being ſuſpended from the branch as ſoon as it is electrified the water will begin to flow, and when the electrification is ſtrong, ſeveral ſtreams will iſſue in form of a cone. This experiment may be diverſified by uſing a fountain made with condenſed air.

RECREATION VI. p. 25

The magic picture.

This picture or print muſt have a frame and glaſs. The border of the print is cut off, all round: the upper and under part of the middle of the glaſs is covered with tinfoil, that communicates by the bottom of the frame: over this tin foil the print is paſted. When the picture is a portrait a crown is placed on its head, which a ſtranger attempting to take off, at the ſame time he holds the frame by the bottom, receives a ſmart ſhock, and fails in the attempt.

RECREATION

RECREATION VII. p. 26
The Tantalian cup.
A metal cup is placed on a ſtool of baked wood, and a chain from the branch is fixed to the cup. A perſon endeavouring to taſte the liquor in the cup, receives a ſhock. The machine being ſtopped, another perſon drinks out of the cup with eaſe: the machine being again put in motion, the firſt perſon again attempts to taſte the liquor, and receives a ſecond ſhock.

RECREATION VIII. p. 26
The circular chimes.
A round board is fixed to a perpendicular axis, and ſeveral glaſs radii iſſue from the board, and to the end of each of them is fixed a braſs thimble. Two wires that are joined to the hooks of the electric table, (Pl. III.) and which are differently electrified, put the wheel in motion, by being properly applied to the thimbles, and the motion increaſes till it goes fifteen times round in a minute. Two ſemicircular ſtands, that hold ſeveral bells, being then brought near the wheel, they are alternately and inceſſantly ſtruck by a radius fixed to the upper part of the axis. This wheel is ſometimes uſed as a jack for roaſting meat, p. 27 (note)

RECREATION IX. p. 28
The ſelf moving wheel.
This wheel is conſtructed on the ſame principle as the foregoing. A circular plate of glaſs, gilt on both ſides, is fixed to a perpendicular axis: on the edge of this wheel are fixed two bullets, one communicating with the upper ſurface, and the other with the under ſurface; twelve ſmall pillars of glaſs, with a thimble on the top of each of them, are fixed in a circular ſtand, round the wheel. When this wheel is well charged, the bullets on its edge being differently electrified, attract and repel the thimbles alternately, and thereby give the wheel a motion that increaſes continually, till it goes more than 20 turns in a minute, and the motion will continue half an hour. The celerity of this wheel may be increaſed by an additional number of bullets.

RECREATION X. p. 29
The magician's chace.
A wire is placed perpendicular to the branch, and on the top of it turn ſeveral horizontal wires, the points of which are

are bent in oppofite directions, and on them are fixed the figures of men, horfes, hounds, &c. When thefe wires are electrified they will turn fwiftly round, and the figures will feem to purfue each other. This Recreation may be improved by another fet of wires, placed over the former; or by giving the figures a progreffive as well as a circular motion.

RECREATION XI. p. 30

The planetarium.

Six concentric hoops of metal are fufpended from the branch; under and near to them is placed a metal plate, on which are put glafs bubbles, between the hoops: thefe bubbles correfpond to the planets, the hoops to their orbits, and a ball hung over the center of the hoops repreſents the fun. When the hoops are electrified the balls will move round them, and the motion will continue as long as the operator thinks fit.

RECREATION XII. p. 32

The incendiaries.

A perfon ftanding on a cake of wax holds a chain that is connected with the branch, and putting his finger into a difh containing fpirit of wine, it will be immediately in a blaze; as if a wick that communicates with the fpirit be laid to a train of gunpowder, it may blow up a magazine, or fet fire to a city. This experiment may be diverfified by making the electricity pafs through feveral perfons that touch each other.

RECREATION XIII. p. 32

The inconceivable fhock.

A perfon holding a chain that is joined to one of the hooks of the electric table, attempts to fix a wire on the other hook, when he inftantly receives a fhock through the body, without knowing from whence it proceeds. This Recreation may be diverfified by concealing the chain under a carpet on which a perfon treads, and by laying a wire that communicates with the other hook, in fuch manner that he may accidentally take hold of it. Methods of communicating the fhock to a great number of perfons at the fame time.

RECREATION XIV. p. 34

Magical explofions.

Gunpowder is made up in the form of a fmall cartridge, in each end of which is put a blunt wire; the ends of thefe wires

wires within the cartridge are about half an inch diſtant. Two chains, that communicate with the two hooks in the electric table, being joined to the external ends of the wires, the electric fire will paſs through the cartridge, with an inſtant exploſion. By a ſimilar method braſs or iron wire may be melted.

RECREATION XV. p. 35

Priſmatic colours.

A tin plate is placed between two wires that communicate with the two hooks of the electric table, and after many exploſions three diſtinct rings appear, each of which contains all the colours of the priſm or rainbow. This experiment corroborates the Newtonian doctrine of colours, p. 35 (note)

RECREATION XVI. p. 36

The artificial earthquake.

An edifice, compoſed of ſeveral looſe pieces, is placed on a board in the middle of a large baſon of water. A wire that communicates with the hooks in the table, being laid over the board and the ſurface of the water, they become greatly agitated by the exploſion, and the edifice is laid in ruins.

RECREATION XVII. p. 37

The electrical kite.

This kite conſiſts of a large thin ſilk handkerchief, whoſe corners are faſtened to the ends of two ſlips of cedar, and to the top of the upright piece is fixed a pointed wire, about a foot long: the other parts are the ſame as in a common kite. To the end of the twine next the hand a ſilk ribband is tied, and where the twine and ribband join a key is hung. This kite is raiſed when thunder is approaching. The electricity is conducted from the wire of the kite to the twine, and from that to the key by which a phial may be charged and all the common experiments in electricity performed. Account of ſome very extraordinary phenomena that were produced by an electric kite in the ſouth of France, p. 38.

Deſcription of an apparatus for drawing the electric fire from the clouds without danger, p. 40.

RECREATIONS IN THE DARK CHAMBER.

RECREATION XVIII. p. 41

The miraculous luminaries.

Method of making the phoſphorus proper for this Recreation. The figure of the moon and ſtars being drawn on a board, a quantity of the phoſphorus is fixed over them, and a number of phials are diſcharged on the phoſphorus, by which the figures are ſtrongly illuminated. The board is then placed againſt the ceiling, and the luminaries appear as ſhining in the zenith.

RECREATION XIX. p. 42

The globular fires.

Theſe fires are produced by the globe and cuſhion only, without the conductor. The globe being ſtrongly excited, parts of circles of fire will appear on both ſides the rubber, and ſometimes completely ſurround the globe. If a finger be brought near the globe, when it is in that ſtate, there will frequently be a complete arch of fire from the finger to the rubber, though it be almoſt on the oppoſite ſide of the globe. If the air be exhauſted from the globe, the electricity will all appear on the inſide.

RECREATION XX. p. 43

The luminous ſhower.

On a metal plate ſet under the branch is put a quantity of braſs duſt, and over it another plate is ſuſpended from the branch, and when it is ſtrongly excited the duſt will be attracted and repelled with great rapidity, and exhibit the appearance of a luminous ſhower. A ſimilar phenomenon by a ſpunge filled with water.

RECREATION XXI. p. 43

The illuminated vacuum.

A wire is cemented in the top of a large exhauſted receiver, and the upper end of the wire is brought to the conductor, when one or more ſtreams of light that reach the whole length of the receiver, appear in a beautiful manner. The appearance of this light is remarkably different, according as the veſſel is electrified poſitively or negatively.

RECREATION XXII. p. 44

The luminous cylinder.

A braſs plate is fixed at the bottom of an exhauſted receiver, and another plate is contrived to let down, near the former.

mer. The electricity paſſes from one to the other of theſe plates, the whole length of the veſſel, and appears as a corruſcation of a bright ſilver hue.

RECREATION XXIII. p. 45

The magical conſtellations.

On a board are marked a number of ſpots, at different diſtances, ſo as to correſpond with the ſtars in two or more contiguous conſtellations. On the ſides of each ſpot are made two holes, in which wires are placed, that nearly meet over the ſpot. The other ends of the wires communicate with the branch, and when that is electrified all the ſtars appear luminous, and ſhine with unfading luſtre as long as the machine is in motion.

RECREATION XXIV. p. 46

The luminous characters.

Several rows of tin-foil, that all communicate, are placed on a board, at equal diſtances (Plate IV. Fig. 1.) From theſe rows the characters are cut out. One end of the tin foil being brought to the conductor, the electric fire would paſs over the whole imperceptibly, but being ſtopped by the breaks in the lines it jumps from one to the other, and all the characters become luminous, and remain ſo long as the operator thinks fit.

RECREATION XXV. p. 47

Priſmatic illuminations.

An exhauſted cylinder is fixed to a lath, and is rubbed by the hand as it turns, when a body of light variegated with all the colours of a priſm, appears in the glaſs, and theſe colours are continually changing. When a little air is let into the cylinder the colours are more vivid: when more air is admitted there are continual corruſcations, with the appearance of a caſcade of fire, trees, moſs, &c.

RECREATION XXVI. p. 48

The aurora borealis.

A Torricellian vacuum is made in a glaſs tube, one end of which is applied to the conductor, and the other end held in the hand; the whole tube then appears to be filled with light, which continues for a conſiderable time: after this light diſappears, if the tube be drawn through the hand, a very intenſe light is ſeen, and reaches, without interruption, from one hand to the other.

RECREATION XXVII. p. 49
The circulating lamps.
To the upper axis of the felt-moving wheel are fixed ſeveral radii, and from the end of each of them hangs a lamp, filled with ſpirit, and that of each lamp is tinged with a different colour. The wheel having acquired a conſiderable velocity is placed under the branch, from which hangs a chain, that as the wheel turns round dips into the ſpirit of each lamp and ſets it on fire. Theſe lamps being all of different colours, and revolving in a quick ſucceſſion, produce a pleaſing effect.

MAGNETISM.
DEFINITIONS, - - - - p. 50
APHORISMS, - - - - - 50
Nature of the magnetic attraction, aph. 1 to 6.—Properties of the magnetic needle, aph. 8 to 10.—Strength of the natural magnets, aph. 10 and 11.—Magnetic quality of iron, aph. 13 and 14.—Methods of communicating and deſtroying magnetiſm, aph. 15 to 17.
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The magnetic perſpective-glaſs, - - - 56
The magnetic wand, - - - - 57

RECREATION XXVIII. p. 58
The communicative crown.
A large ſewing needle, that is ſtrongly touched, is concealed in a crown piece. You deſire a perſon to lend you a piece of the ſame ſort, which you change for the other, and giving that to the perſon, you diſcover whether it be incloſed in a ſnuff box, or not, by holding the magnetic perſpective over the box.

RECREATION XXIX. p. 59
The magnetic table.
A magnet is concealed under a table, and is moveable by a pin, at one end of it. Small nails are laid on that part of the table where the magnet then is, and they are attracted by a key you hold over them. You change the poſition of the magnet, by the pin, and give the key to any one, when it will not attract the nails. You change the poſition of the magnet a ſecond time, and giving the key to another perſon, it will immediately attract the nails.

RECREATION

RECREATION XXX. p. 60
The myſterious watch.
You aſk any one to lend you his watch, and placing it over that part of the table mentioned in the laſt Recreation, where the magnet is, it will preſently ſtop. You change the poſition of the magnet, and deſire the perſon to lay his watch in the ſame place, when it will not ſtop. You move the magnet a ſecond time, and giving the watch to another perſon, it will ſtop as before.

RECREATION XXXI. p. 60
The bouquet.
A ſmall box of thin wood (Pl. VII. Fig. 1.) is contrived to contain two artificial flowers; the principal ſtalk of each of them is ſtrongly touched, but in different directions. By holding the magnetic perſpective over the box you diſcover which of the flowers is concealed in it.

RECREATION XXXII. p. 61
The magnetic dial.
A magnetic needle is concealed in a hollow circle, (Plate VII. Fig. 2.) and oppoſite its north end a pin is fixed in the border of the circle; over the needle is placed a dial, that moves freely in the hollow circle, and on which are numbers, &c. A perſon draws a ticket from a bag, in which there are ſeveral diviſions, and then turning the hand of the dial about it ſtops at the number he has drawn; you having previouſly ſet the north end of the magnet, by the pin in the circle, to that number on the dial.

RECREATION XXXIII. p. 63
The magnetical cards.
This Recreation is ſimilar to the laſt, but here inſtead of the numbers of the hours, one of each of the four ſuits of the cards, are drawn, and the eight names of the cards of piquet are wrote (Plate VII. Fig. 4.) You offer a piquet pack to a perſon that he may draw a card taking care that he draws the long card, as is explained in the firſt volume. He then turns the needle round, and it ſtops at the card he drew: you having previouſly placed the magnet againſt that card. This Recreation may be diverſified by having two needles, and letting two perſons draw each a different long card.

RECREATION XXXIV. p. 64
The dextrous painter.
There are two ſmall boxes and four ſmall boards, (Pl. VIII. Fig. 1.) on which different ſubjects are painted, and in each of which a magnet is concealed. There is likewiſe a ſmall circle of paſteboard, Fig. 2, on which are drawn the ſame ſubjects as on the boards: this circle turns on a pivot, and contains a magnet. A perſon places any one of the four boards in one of the boxes privately, and you place the other box with the paſteboard circle over it; when the magnet in the board will turn the circle, till that part of it which is under an opening made in the top of the box, preſent the ſame picture as that on the board and which is ſuppoſed to be drawn by a little painter concealed in the box.

RECREATION XXXV. p. 66
The cylindrical oracle.
In the ſide of a hollow cylinder (Plate IX. Fig. 1.) is concealed a magnetic bar: on its cover is a circle, with numbers, and at the center of that circle is a pivot, on which a magnetic needle turns. A perſon draws a queſtion out of one of the diviſions of a bag, and turning the needle at the top of the cylinder it ſtops at the number with which the anſwer contained in the cylinder is marked; you having placed that number over the magnetic bar when you put the cover on the cylinder. Example of the different anſwers that may be given to the ſame queſtions.

RECREATION XXXVI.
The myſtical dial.
There is to be a ſmall box (Plate IX. Fig. 2.) and four boards, Fig. 3; in each of theſe boards a magnet is placed, in a different poſition, and on it a different number is wrote. A perſon is to place one of the boards in the box, and to chooſe whether the needle of the dial, Fig. 4. when placed over the box, ſhall point to the whole, the the half, the double, or triple of the number on the board; and you then place the dial on the box in a determinate poſition.

RECREATION XXXVII. p. 68
The enchanted cover.

A hollow cone is placed in a ewer (Plate X. Fig. 1.) at the bottom of which is a hole: under that hole a convex mirror, and between the hole and the mirror is a paſteboard circle, Fig. 3, that turns on a pivot. The ewer is placed on a ſtand, Fig. 1, in which is a drawer. The paſteboard circle is divided into four parts, in three of which are painted the ſame figures as on three of the boards, Fig. 5, and the fourth is left blank: this paſteboard circle contains a magnetic needle, and the four boards have each a concealed magnet; therefore when one of them is put in the drawer under the ewer, this circle will correſpond to the poſition of that magnet, and a perſon looking into the top of the ewer will ſee his own face ſurrounded with the head dreſs of the figure in the drawer.

RECREATION XXXVIII. p. 70

The magician's circles.

There are two hollow ſquares that are connected by a croſs piece which is alſo hollow (Plate X. Fig. 5.) On each of the ſquares is a dial, with a moveable hand, and within the ſquares and croſs piece is a movement, ſo contrived that when the hand of one of the dials is moved, that of the other ſhall place itſelf in a determinate poſition. On theſe dials are to be wrote certain words, taken from the tables conſtructed for the purpoſe, and when the hand of one dial is placed to a certain number of words in ſucceſſion, that of the other directs itſelf to words which compoſe the anſwer. Method of varying this Recreation.

RECREATION XXXIX. p. 73

The box and dice.

At one end of a long hollow caſe or pedeſtal (Plate XI. Fig. 1.) is a drawn circle, divided into twenty equal parts, in which are marked the points that can be thrown by two dice. At the center of this circle is placed a magnetic needle, which is directed by a bar underneath it. At the other end of this pedeſtal is a vaſe that has different diviſions, in which dice are placed, that ſeem to be thoſe thrown in at the top of the vaſe. When the needle is turned round it will ſtop at thoſe points in the circle that anſwer to thoſe on the dice in the vaſe: the bar underneath the circle having been previouſly ſet to thoſe points.

RECREATION XL. p. 75

The box of flowers.

There

There are two cafes, (Pl. XI. Fig. 3 and 4.) in each of which two flowers are placed, and in each of them is concealed a magnetic bar, fixed in a certain direction: thefe cafes are put in a box of very thin wood, Fig. 2. and when the magnetic perfpective is held over them, it is readily difcovered, by the direction of the needle, what flower is in that part of the box.

RECREATION XLI. p. 76

The box of metals.

At the bottom of a box whofe cover is as thin as poffible, (Plate XII. Fig. 1.) are fix holes, exactly fimilar, and in thefe holes are placed tablets, that each of them contain a magnet, in a different pofition, and that is covered with a thin plate of different metal. There is a magnetic perfpective, Fig. 2, that has two circles marked with the letters of the different metals, and from its center is drawn an index. If this perfpective be held over any one of the tablets, in fuch manner that its index is perpendicular to the fide of the box, the needle in the perfpective will point to the letter of the metal over which it then is. This box of metals is far preferable to thofe formerly exhibited, p. 77.

RECREATION XLII. p. 78.

The magnetic oracle.

There are eight tablets that each contain a magnet, in a different pofition; there is alfo a dial marked with the digits from 1 to 8, (Plate XII Fig. 5.) and thirty-two fmall rundlets that have the fame numbers. On the tablets queftions are wrote, and four of the rundlets contain different anfwers to each queftion. A perfon puts the dial over any one of the tablets, and turning the hand round it ftops at the number which is marked on the rundlets that contain the anfwer.

RECREATION XLIII. p. 79

The incomprehenfible card.

A very thin fteel magnet is concealed in a card. You prefent a pack to a perfon that he may draw one, and offer the card with a magnet: he is then at liberty to conceal the card, or replace it, privately, in the pack, and you tell, by your perfpective, whether it be there or not.

RECREATION XLIV. p. 79

The two magical cards.

At

At the bottom of a ſmall box (Plate XII. Fig. 6.) a pivot is placed, on which turns a paſteboard circle that contains a touched needle, and on which two cards are painted; and in the top of the box is a hole, by which thoſe cards are viſible. You are to have a pack of cards that has a long and wide card, which are the ſame as thoſe in the box: theſe two cards are to be drawn by two perſons, and by applying your magnetic wand to the box, either of the cards becomes viſible, at pleaſure.

RECREATION XLV. p. 80.

The magnetic planetarium.

A round moveable paſteboard is placed at the bottom of a box, (Plate XIII. Fig. 1.) at its center a circle is drawn, and ſeven other circles round that; and croſs each of theſe a magnet is fixed. Over this paſteboard another is placed, on which are drawn eight correſponding circles; in that at the center ſeven queſtions are wrote, and in the others are words that anſwer thoſe queſtions, and on each of theſe circles turns a magnetic needle. The lower circle is moved by a hand fixed to its axis, which comes through the upper circle; and when the lower paſteboard is moved, the attraction of its magnets moves all the needles on the upper board. A perſon therefore ſetting the hand to any one of the queſtions in the centrical circle, the needles on the other circles immediately point to the words that compoſe the anſwer.

CONSTRUCTION OF THE MAGNETICAL AND MECHANICAL TABLE. p. 83

Under the top of this table, (Plate XIV. Fig. 1.) and about one inch and a half from it, is another ſurface, on which is placed the magnetic apparatus, by which the ſubſequent recreations are performed. The legs of this table, Fig. 2, are hollow, and through them, and the ſtep that joins to them, goes a cord, that comes out behind the partition, and paſſing over a pulley, plate XV, has a weight joined to the end of it, and to it is likewiſe fixed an index. On the upper ſurface of this table are placed, in ſucceſſion, three circles, (Plate XIV. Fig. 1, 4, and 5.) on whoſe circumference are different numbers of diviſions, that correſpond to the diviſions in the ſevaral columns of the table, Plate XV. One of theſe circles is placed on that part of the table which is over the magnetic bar; on the circle is placed a ſhallow baſon with water in which floats the figure of a ſiren, that contains a touched needle:

dle: therefore, when the perſon behind the partition places the index on the cord againſt any diviſion of the table, he will, by moving the magnetic bar under the circle, make the ſiren point to a letter or number in a correſponding diviſion of that circle.

RECREATION XLVI. p. 86

To make the ſiren of the magnetic table point to all the letters of a given word.

On three cards that are each of a different ſize, are wrote the names of three perſons or cities. Theſe three cards being given to any perſon, he keeps one of them, and returns you the other two, which you lay aſide without looking at them, and the ſiren immediately points to the letters that compoſe the word on the card the perſon has taken. For you diſtinguiſh by the touch which of the three cards is choſe, and by certain words previouſly agreed on, make it known to the confederate.

The ſiren is to point out the time expreſſed by any given watch. p. 87.

A part of the ſtep on which the operator ſtands goes through the partition, and is moveable, like a lever. The watch is laid on the table, and the operator preſſes down the ſtep with his foot as many times as are equal to the number of hours; which the confedgrate behind the partition obſerving, makes the ſiren point to that number. A ſimilar ſignal is then made for the quarters and minutes.

To make the ſiren point to three numbers that have been choſen by three different perſons. p. 89.

Theſe three numbers are drawn from a bag, in which there are ſeveral diviſions, and the confederate knowing what thoſe numbers are, makes the ſiren point to them.

A perſon having drawn a card from the pack, the ſiren points to the name of that card on the circle. p. 88.

A queſtion being propoſed, the ſiren gives the anſwer; though the perſon who exhibits the Recreation does not know the queſtion. p. 88.

On five cards are wrote five different queſtions, but which may be all anſwered by one word. A perſon chooſes any one of theſe cards, and lays the reſt aſide: the confederate knowing

knowing the word that will anſwer it, makes the ſiren point to the ſeveral letters which compoſe that word.

RECREATION XLVII. p. 89

The ſagacious ſwan.

On the top of an oblong box (Plate XVI. Fig. 1.) is placed a ſhallow baſon, in which floats the figure of a ſwan, that contains a touched needle. Round this baſon are placed ſix ſmall vaſes, and in each of them is put an anſwer to a queſtion. At the other end of the box is an ivory egg, on a hollow ſtand. There are ſix etwees, Fig 3, of different lengths, and that each contain a queſtion. A perſon having choſe one of the etwees, takes out the queſtion, and puts the etwee into the egg, and by ſhutting down the top of the egg preſſes the etwee down the hollow ſtand, and againſt a movement in the box, Fig. 2, by which mean a magnetic bar is brought under a particular part of the baſon, according to the length of the etwee, and the ſwan is thereby directed to the vaſe that contains an anſwer to the queſtion.

THE COMMUNICATIVE BELL. p. 91

In a hollow circular box, (Plate XVII. Fig. 1.) there is fixed a ſmall bell, and at the center of the box is a pivot, on which is placed a touched needle, that has at each end a ſmall braſs knob. The bottom of this box is covered with gauze. This box is placed on the magnetic table, over that part where there is a magnetic bar, by moving of which the touched needle on the pivot is made to ſtrike the bell.

RECREATION XLVIII. p. 92

To tell, by the communicative bell, the card that a perſon has drawn from the pack.

The ſounding of the bell ſignifies *yes*, and its ſilence *no*.—You are to preſent the pack in ſuch manner that the perſon will naturally draw the card you offer, and which is known to your confederate. You then aſk ſeveral queſtions of the bell, which your confederate reſolves, either by making it ſound or remain ſilent.

To tell by the bell at what number from the top any card of a pack is placed, that a perſon ſhall name, p. 93.

The cards of piquet being previouſly packed, they are to be ſhuffled in the manner directed in the firſt volume, and they will then be in a determinate order; of which the confede-

confederate having a copy, and hearing the name of the card the perſon has choſe, makes the bell ſtrike the number at which it is from the top.

RECREATION XLIX. p. 94

The magnetic balance.

A pair of ſteel ſcales, that are gilt and very true, (Plate XVII. Fig. 2.) are ſuſpended over the magnetic table, near the part under which the bar is placed. Two pieces of money that are preciſely of the ſame weight being put in theſe ſcales either of them is made to preponderate at pleaſure. The confederate, at a ſignal given, bringing the bar under one or other of the ſcales.

RECREATION L. p. 94

The ſympathetic dials.

One of theſe dials has a catch on the outſide, by which it is ſtopped at pleaſure: the other has a ſteel catch within the caſe, that takes the fly off the movement. A large bar in the magnetic table, when brought under this dial, attracts the catch, and puts the wheels in motion, but when the bar is moved from it, the motion ceaſes immediately. You therefore give the dial with the ſtop to a perſon and tell him that when he ſtops that dial, or puts it in motion, the other on the table will, by ſympathy, ſtop or move alſo; and by mounting the ſtep you make it act accordingly.

CONSTRUCTION OF THE MAGNETIC ROLLER. p. 96.

This roller conſiſts of a long and narrow piece of wood, (Plate XVII. Fig. 5.) on which are ten circles, and in each of them a magnet in different directions from the others. This roller is placed at the bottom of the magnetic table, and moves upon two cylinders, being drawn by a ſtring that goes down a leg of the table, through the partition, and over a pulley placed on the other ſide of it: to this ſtring a weight and an index are faſtened. Under the pulley is placed a table, p. 220, that has five columns, which contain numbers, letters, the names of cards, countries, &c. and in each of theſe columns are ten diviſions, that correſpond to the ten circles on the roller: ſo that when the index on the ſtring is ſet by the confederate, againſt any one of thoſe diviſions, the circle on the roller that anſwers to it is brought to a certain part of

of the magnetic table, that the bar it contains may act on the needle of some machine to be placed over it.

RECREATION LI. p. 98

The magician's box.

In a small hollow box (Pl. XVIII. Fig. 1.) is placed, on a pivot, a pasteboard circle, Fig. 3, which has ten equal divisions, in five of which cards are painted, and in the middle of it is a magnetic needle. In the top of the box is a hole, nearly of the same size with one of the divisions on the circle. Over this box is placed a glass cover, Fig. 2, and when it is put on the magnetic table, over the roller, any part of the circle may be made visible by bringing the proper circle of the roller under it. A similar experiment with a circle that has the names of five cities wrote on it, instead of the cards, p. 100.

RECREATION LII. p. 100

The mystical dial.

This dial has ten divisions. in which are wrote the nine digits and a cypher, and it has a magnetic needle for an index, which points to any one of the ten divisions on the circle, according to the position of the magnet in the part of the roller over which it is placed. Method of showing by this dial the numbers that two persons have chose, their sum, or their product, p. 101.

RECREATION LIII. p. 102

The magical game of all fours.

There must be a circle with twelve divisions, on six of which cards are painted and to which six of the divisions of the roller correspond. A pack of cards are previously disposed, according to the manner explained in the first volume; so that after the cards are dealt they can be played only one way. The other person plays his cards, yours remain on the table, and every time you are to play you direct another person to look in at the top of the box, (Pl. XVIII. Fig. 2.) and see what card is played, your confederate having brought the proper card in view, by moving the roller.

RECREATION LIV. p. 103

The intelligent fly.

The space between two concentric circles contained in the box (Pl. XVIII. Fig. 5.) is divided into ten equal parts, in each of which a letter is wrote; and at the center of the

circle, is placed a pivot, that holds a magnetic needle, at the end of which is the figure of a fly: all the needle, except that part to which the fly is fixed, is concealed by a paper placed over it. There are laid on a table a parcel of cards, properly packed, and on each of them a queſtion is wrote. You aſk a perſon at what number the card ſhall be to which the fly ſhall give him an anſwer. When he has determined, you place the box over the roller, and your confederate knowing the queſtion on the card, makes the fly point to the letters that compoſe the anſwer.

RECREATION LV. p. 105

The multifarious verſe.

On eight tablets that are of the ſame ſize, and that exactly fill a box, (Plate XIX. Fig. 1.) are wrote the eight words of a Latin verſe, and in each of them is placed a magnet in a different poſition. Over this box is placed a board, Fig. 2, that has eight circles, whoſe centers are directly over thoſe of the tablets: round each of theſe circles are wrote the eight words of the Latin verſe, and on each of them is placed a needle. Over the board and box is placed a glaſs frame. Fig, 3. If a perſon put the tablets in any poſition privately, then cover the box over with paper, and place it under the board, the needle on each circle will point to the word on the tablet under it; ſo that by looking into the top of the box you will always know in what order the tablets are placed.

RECREATION LVI. p. 107

The communicative mirror.

In a box (Plate XX. Fig. 1.) is placed a pivot, on which is fixed a paſteboard circle, Fig. 2, that has a touched needle, and on which are painted three cards. Over this paſteboard is a hole, in the top of the box, and over that is placed a hollow glaſs pedeſtal, on which is fixed a tube, containing an inclined mirror. There are three tablets that have each a card, ſimilar to thoſe on the circle, and a magnetic bar. One of theſe being placed in the box, Fig. 3, and that put in the other box, Fig. 1, under the circle, it will place itſelf in a correſponding poſition: ſo that a perſon looking into the tube will ſee the ſame card as that on the tablet concealed in the box, and he will ſeem to ſee it in the mirror placed oppoſite the tube.

RECRE-

RECREATION LVII. p. 108.
The box of dice by reflection.
At each end of a long box (Pl. XX. Fig. 4.) is a small hole, and over the ends are placed two hollow cubes; under each of these cubes is an inclined mirror, and a small touched needle on a pivot. The top and two longest sides of this box are of glass, lined with a thin paper. There are two dice, that have concealed in each of their sides a small magnet: so that when these dice are placed in the cubes, in any position, you will see, by looking in at the hole at each end of the box, the position of the needle under each cube, and consequently discover which side of each die is next the top of the box.

PNEUMATICS.
DEFINITIONS - - - - - - 110
APHORISMS - - - - - - 110
Properties of air, aph. 1 to 9.—Of the atmosphere, aph. 10 and 11.—Of the wind, aph. 12 and 13.

PNEUMATIC APPARATUS.
Construction of the common air-pump - - 112
The animometer - - - - - - 113
The circular hygrometer - - - - - 114
The perpendicular hygrometer - - - 115
The thermometer - - - - - - 116
The barometer - - - - - - 117
Rules for predicting the weather by the barometer 119

RECREATION LVIII. p. 120
The bottles broke by air.
A bottle is placed over the hole in the plate of the air pump, and the internal air being exhausted the bottle is broke by the weight of the external air. The same effect is produced by the spring of the air in the bottle, when the weight of the external air is taken off. A person's hand, when laid on the mouth of the receiver, is pressed by a great weight.

RECREATION LIX. p. 121
The brass hemispheres.
These hemispheres being placed close together, and the air exhausted from them, a force equal to one hundred and eighty-seven pounds is required to separate them.

RECREATION LX. p. 121.
Water boiled by air.
A veſſel with hot water is placed in the receiver, and the air being exhauſted the water boils with great rapidity.

RECREATION LXI. p. 122
The aerial bubbles.
A piece of ſtone or iron being put in a veſſel of water placed in the receiver, and the air exhauſted, a great number of bubbles, reſembling drops of dew, riſe on the ſurface of the body in the water.

RECREATION LXII. p. 122
The floating ſtone.
A piece of cork is tied to a ſtone that will juſt ſink it, in a veſſel of water placed in the receiver, and the air is exhauſted, when the ſtone and cork float on the ſurface of the water.

RECREATION LXIII. p. 122
The withered fruit reſtored.
A ſhrivelled apple being placed in the receiver, and the air exhauſted, it is plumed up, and looks as fair as when firſt gathered.

RECREATION LXIV. p. 123
The vegetable air bubbles.
Part of a plant is put in a veſſel of water placed in the receiver: when the air is exhauſted that in the plant ariſes from the extremities of all its veſſels, and preſents a beautiful appearance.

RECREATION LXV. p. 123
The mercurial rod.
A piece of ſtick is put in a veſſel of mercury, in the receiver, and the air exhauſted: when it is let in again it forces the mercury into the ſtick, which is then ſeveral times heavier than before, and when cut the mercury glitters in every part.

RECREATION LXVI. p. 124
The myſtical bell.
A wire that is faſtened to a bell in the receiver goes through the top of it; when the air is exhauſted and the bell ſhook by

by the wire, no ſound is heard; but as the air is let in again the ſound becomes continually more audible.

RECREATION LXVII. p. 124
Feathers heavier than lead.
A piece of lead is hung to one end of a balance, and as many feathers to the other end as will keep the balance in equilibrio; but when it is put in the receiver, and the air exhauſted, the feathers will preponderate.

RECREATION LXVIII. p. 124
The ſelf-moving wheel.
A wheel with ſmall vanes is placed in the receiver, and the air exhauſted; when it is let in again, by a ſmall cock, it ruſhes againſt the vanes and puts the wheel in motion. If the pump be continually worked, the motion of the wheel will be perpetual, without any apparent mover.

RECREATION LXIX. p. 125
The animated figures.
Several perpendicular cylinders are fixed in a circular frame; in each cylinder is placed the figure of an animal, under which is a piſton, and under that a ſpring; and at the bottom of the cylinder is a ſmall hole. When this machine is placed in the receiver and the air exhauſted, the figures all riſe up out of the cylinders; and when the air is let in again they all retire to their ſeveral apartments.

RECREATION LXX. p. 126
The artificial halo.
A candle is placed on one ſide of a receiver, and a ſpectator on the other; as the air is exhauſted the light of the candle is refracted into circles of various colours, like thoſe of a halo.

RECREATION LXXI. p. 126
The mercurial ſhower.
A piece of wood is cemented to the top of the receiver, and mercury poured over it. The preſſure of the air, as the receiver is exhauſted, forces the mercury through the wood in the form of a ſhower, that is ſometimes luminous in the dark.

RECREATION LXXII. p. 126
The fountain in vacuo.
A tube that is hermetically ſealed at one end, and cloſed by

a ſtop-cock at the other, is placed on the receiver, and when the air is exhauſted from the tube it is immerſed in water, which will then play up in the tube, in the form of a fountain.

RECREATION LXXIII. p. 127

The air gun.

The air-gun conſiſts of two barrels (Plate XXIII. Fig. 1.) and a ſyringe that condenſes the air between the barrels. Near the ſtock of the gun is a valve and a trigger, by which the air is admitted behind the ball and forces it out. Some air-guns contain ſeveral balls, which they diſcharge ſucceſſively.

RECREATION LXXIV. p. 127

Artificial rain or hail.

In a hollow cylinder (Pl. XXIII. Fig. 3.) that has five oblique partitions, and a ſmall hole in each of them, is placed a quantity of lead ſhot, and when the cylinder is turned round, the ſound of the ſhot, in paſſing through the partitions, reſembles that of rain or hail, according to the ſize of the ſhot.

RECREATION LXXV. p. 128

The magical flowers and fruit.

The ſtem of an artificial orange tree, that is hollow, (Pl. XXIII. Fig. 4.) is placed in a copper veſſel, in which there is a quantity of condenſed air, and when a cock is turned, the air ruſhing up the tree, forces out the artificial fruit concealed in the end of the branches.

HYDROLOGY.

DEFINITIONS - - - - p. 131
APHORISMS - - - - p. 131

The properties of water, aph. 1 to 6.—The laws of fluids in general, aph. 7 to 12.—Properties of ſolid bodies immerſed in fluids, aph. 13 to 16.

THE HYDROLOGIC APPARATUS.

Properties of the ſyphon - - - 134
The ſeveral ſorts of pumps - - - 135
The hydrometer - - - - 137
The hydroſtatic balance - - - 140
The ſcrew of Archimedes - - - 143
The balance pumps - - - - 143
The hydraulic ſcoop - - - 144

RECREA-

RECREATION LXXVI. p. 145
The hydroſtatic bellows.
Two circular horizontal boards (Pl. XXVI. Fig. 5.) are joined by leathers, and in the upper board is fixed a perpendicular braſs pipe. If a man ſtanding on the board, blow into the tube, he will raiſe himſelf up, or if water be poured in, a large weight will be raiſed.

RECREATION LXXVII. p. 145
The water clock.
A glaſs cylinder (Pl. XXVII. Fig. 1.) has a ſmall hole at the bottom, by which water drops out. On the ſurface of the water floats a glaſs tube, whoſe neck is confined by the cover of the cylinder, and as it deſcends ſhows the hour, by a ſcale marked on it.

RECREATION LXXVIII. p. 146
The globular fountain.
Over the jet of a fountain is placed a pipe, and at the end of that a hollow globe, in which a number of ſmall holes are made: the water of the fountain ruſhing up the pipe enters the globe, and being forced out of its holes forms a ſphere of water.

RECREATION LXXIX. p. 147
The hydraulic dancer.
A ſmall figure of a man (Pl. XXVII. Fig. 2.) is made of cork, and within it is placed a cone of leaf braſs: this figure being placed on the top of a jet will remain ſuſpended, and perform a variety of motions. A ſimilar experiment is made with a light ball of copper, Fig. 3.

RECREATION LXXX. p. 147
The hemiſpherical caſcade.
To the top of a jet is ſcrewed a pipe that enters the bottom of an inverted cone (Plate XXVII. Fig. 5.) the water from the pipe falling into the cone runs over it in form of a hemiſpherical caſcade. If this fountain be reverſed, it will have the form of a vaſe, Fig. 6.

RECREATION LXXXI. p. 148.
The water ſun.
Two ſmall portions of a ſphere (Pl. XXVII. Fig. 7.) are joined together, and fixed to a pipe from whence a jet flows: near that part where the portions of the ſpheres join

join are a number of holes; and the water rushing violently into the cavity is forced out of the holes, in the figure of the sun. Several pieces of this sort may be placed over each other, and the same pipe may supply them all, as in Fig. 8.

RECREATION LXXXII. p. 148

The revolving water-sun.

A number of small tubes are fixed in the side of a hollow circle, (Plate XXVIII. Fig. 1.) which is placed over a jet, in such manner that it will turn freely round. The water rushing into the hollow circle keeps it in continual motion, and at the same time forcing out of the tubes, forms the figure of a revolving sun.

RECREATION LXXXIII. p. 149

The phial of the four elements.

Glass, finely powdered, oil of tartar, tincture of salt of tartar, and distilled rock oil are put into a phial, and shook together; after a short time they separate, and each assumes its place, according to its specific gravity: the glass at bottom representing the earth, the oil of tartar the water, the tincture the air, and the rock oil, which mounts to the top, the element of fire.

RECREATION LXXXIV. p. 149

The magic bottle.

A bottle with a very small neck, being filled with wine, and placed in a vessel of water, (Plate XXVIII. Fig. 2.) the wine will come out of the bottle and float on the surface of the water, which will descend and fill the bottle. A similar effect is produced by filling the bottle with water, and placing it, with the mouth downward, in a vessel of wine.

RECREATION LXXXV. p. 150

The compound jet d'eau.

A tube with a very small orifice is inserted in the neck of a copper vessel, (Pl. XXVIII. Fig. 6.) in which there is a cock. Air is first injected by a syringe, and then water, and the cock is turned. This vessel contains an extempore jet d'eau; for whenever the cock is opened, the water rushes out with great violence.

RECREATION LXXXVI. p. 150

The marvellous vessel.

At

At the bottom of a tin veſſel, that has a narrow mouth, there are a great number of very ſmall holes. This veſſel is plunged in water, and corked when it is full, and as long as it remains ſo no water will come out, but when it is uncorked the water will run out of the holes at the bottom of the veſſel. An experiment on the ſame principle, by placing a paper over a glaſs filled with water, then inverting the glaſs and drawing the paper away; when the water will remain ſuſpended in the glaſs.

RECREATION LXXXVII. p. 151

The circulating fountain.

This fountain has two boxes, the uppermoſt of which is ſupported by two hollow pillars (Pl. XXVIII. Fig. 5.) And on that box is placed a baſon, into which water being poured, it runs down one of the pillars, into the lower box, and driving the air up the other pillar, into the upper box, forces the water up a pipe and forms a fountain. The water falling into the baſon, deſcends by the pillar, in the ſame manner as before, and making a freſh impulſe on the water in the upper baſon, by forcing the air up the other pillar, the fountain is kept continually playing, as long as any water remains in the upper box.

RECREATION LXXXVIII. p. 152

The magical caſcade.

In a tin veſſel, (Pl. XXVIII. Fig. 4.) water is poured, and in the center of it is fixed a pipe, whoſe upper end is above the water in the veſſel: to this pipe are joined four arms, by which it is ſupported over a baſon, at the center of which is a ſmall hole. At the bottom of the veſſel are ſeveral ſmall tubes, by which the water runs into the baſon; but when it riſes above the lower end of the pipe in the centre of the veſſel, the circulation of the air being ſtopped, the tubes ceaſe to flow. When ſo much of the water is run out of the baſon as to admit the air to enter the pipe, the tubes flow again: and thus they alternately flow and ſtop, as long as any water remains in the veſſel.

RECREATION LXXXIX. p. 153

The illuminated fountain.

This fountain is formed by two cylindrical veſſels that are connected by four pipes, (Plate XXVIII. Fig. 7.) On the lower veſſel is placed a baſon, from which goes a tube,

tube, that reaches almoſt to the bottom of the veſſel, and by which water is poured into it. To each of the pipes a candleſtick is joined, and when the candles are lighted, the air in the pipes being rarified, that in the upper veſſel ruſhes down the pipes, and preſſing on the water in the lower veſſel, makes it riſe out of the tube, in form of a fountain: but when the candles are extinguiſhed, and the circulation of the air ſtopped, the fountain no longer plays.

RECREATION XC. p. 154

The ſolar fountain.

A globe of thin copper, half filled with water, is placed on a frame (Pl. XXVIII. Fig. 8.) There is a communication between the lower part of the globe, and a pipe placed in a baſon at the bottom of the frame, by one of the legs, which is hollow. Near the pipe in the baſon is a cock, by which the communication may be ſtopped. When the ſun ſhines on the globe the air within it being rarified, preſſes on the water, and forcing it down the leg of the frame opens a valve at the bottom, and the water riſes out of the pipe in the baſon, in form of a fountain. At night the cold air preſſing on the adjutage ſhuts the valve, and ſtops the fountain; and at the ſame time preſſing on the water in the baſon, forces it back into the globe, ſo as to fill it to the ſame height as before.

RECREATION XCI. p. 155

The cup of Tantalus.

In a tall narrow cup (Pl. XXIX. Fig. 1.) is placed an image, in which is concealed a ſyphon, that beginning at one foot riſes to the upper part of the breaſt, and from thence deſcending through the other foot, on which the image ſtands, goes out at the bottom of the cup. Therefore, when the liquor poured into this cup riſes to the chin of the image, it begins to run out.

RECREATION XCII. p. 156

The ſea gage.

This inſtrument conſiſts of a hollow globe, (Pl. XXIX. Fig. 2, and 3,) to which is fixed a tube, that is immerſed in a veſſel of mercury, on which floats a ſurface of treacle; and to the bottom is hung a weight, ſufficient to ſink the whole machine. While this inſtrument is ſinking the water will force the mercury and treacle up the tube, according to the depth it has deſcended, and the mark of the

the treacle on the tube ſhows to what height it has been forced. When the machine comes to the bottom, the weight ſtriking againſt the ground is diſengaged, by means of a catch and a ſpring, and the other parts of the machine riſe to the ſurface of the water. By the addition of the ball and tube, Fig. 3, the ſea may be ſounded to the depth of 13200 feet, that is, two miles and a half, p. 114.

RECREATION XCIII. p. 158

The diving bell.

This machine is in form of a bell, (Pl. XXIX. 4.) and is coated with lead. In the top is fixed a glaſs, to let in the light and a cock to let out the foul air. Near the bottom is a circular ſeat for the divers to ſit on. This bell is ſupplied with air by two barrels, that are let down and up alternately: and it is ſo light in fair weather, that the divers can ſee to read diſtinctly. This machine is let down from the ſhip by a ſprit faſtened to the maſt-head. There is a contrivance to diſpatch a diver to the diſtance of a hundred yards, p. 160. Conſtruction of a different machine for a ſingle perſon, Fig. 5. p. 161.

PYROTECHNICS.

DEFINITIONS - - - - - - - - p. 163

APHORISMS - - - - - - - - p. 164

Abſolute and relative heat, aph. 1 to 3.—The effects of fire on other bodies, aph. 4 to 9.—Other properties of fire, aph. 10 to 12.

RECREATION XCIV. p. 165

The inflammable phoſphorus.

The meal of any vegetable is put into an iron pan, where it is heated till it becomes a black powder. To one part of this powder are added four parts of alum, and the whole put into a phial, and placed in a ſand heat, and gradually raiſed till the glaſs and matter is red hot; the neck of the phial is then cloſed with wax. A ſmall quantity of this powder being ſhook out, immediately takes fire and burns. This phoſphorus will retain its virtue, if it be kept from the air, for three months.

RECREATION XCV. p. 167

The liquid phoſphorus.

A ſmall piece of common phoſphorus is boiled in water, and the mixture is put in a phial, which is ſealed up. This mixture

mixture ſhines in the dark for ſeveral months, when the phial is ſhook. Pleaſing recreations to be made with this phoſphorus.

RECREATION XCVI. p. 167

The fulminating gold.

To a diſſolution of gold in aqua regia common water is added, and to that mixture, the ſpirit of ſal ammoniac: the gold that precipitates is taken out and dried. A grain of this powder put in a ſpoon, over a candle, will go off with a loud report.

RECREATION XCVII. p. 168

The burning fountain.

An eolipile, containing ſpirits of wine, is placed in a veſſel of boiling water, (Pl. XXX. Fig. 11.) To the eolipile is joined a pipe whoſe orifice is extremely ſmall. The ſpirit is forced out of the eolipile by the heat of the water, and when a candle is brought near the veſſel, the ſpirit takes fire, and continues to burn, for ſome time. This phenomenon improved by ſifting over it the filings of iron.

RECREATION XCVIII. p. 168

Prince Rupert's drop.

A ſmall quantity of melted glaſs is dropped into water, where it aſſumes the form of a drop, with a ſmall tail; and when that tail is broke the whole drop burſts with violence into a fine powder. Conjecture on the cauſe of this phenomenon, p. 169.

RECREATION XCIX. p. 169

The revivified roſe.

A faded roſe is held over the fumes of ſulphur, when it becomes quite white: it is then dipped in water, and after five or ſix hours it becomes quite red.

RECREATION C. p. 169

Writing on glaſs by the rays of the ſun.

In a glaſs decanter, well ſtopped, that contains a diſſolution of chalk in aqua fortis, is put a diſſolution of ſilver. On the decanter is paſted a paper, from which letters are cut out, and when it is ſet in the ſun the parts on the glaſs that form the letters turn black.

RECREATION CI. p. 170

The magic picture.

Between

Between two pieces of glaſs placed at one-twentieth of an inch from each other, a diſtillation of hog's lard and white wax is poured. A coloured print is paſted with its face to one of the glaſſes, and the whole is put in a frame. When the mixture is cold the print is inviſible, but when the glaſſes are heated the print appears as if there was only one glaſs before it.

RECREATION CII. p. 171

The luminous oracle.

In the front of an upright tin box, (Pl. XXXII. Fig. 1.) is a ſmall ſquare hole, and in the back is a door by which candles are put in. In the two ſides are grooves, in which ſlide a double glaſs prepared as in the laſt recreation: behind this glaſs is paſted a black paper, from which letters are cut out, that anſwer queſtions wrote on cards. When a part of the glaſs that contains a particular anſwer is drawn up, before the hole, the heat of the candles makes the letters become viſible.

RECREATION CIII. p. 172

To produce the appearance of a flower from its aſhes.

In the front of a tin box, (Pl. XXXII. Fig. 4.) is a glaſs; behind it is a ſmall tin tube, in which a flower is placed, and behind that a double glaſs, prepared as in the 101ſt Recreation. You preſent a flower, ſimilar to that in the tube, to a perſon, which he throws on a chafing-diſh of hot coals; you then place the chafing-diſh under the box, and the heat makes the flower in the tube gradually viſible.

RECREATION CIV. p. 173

To produce fire by the mixture of two cold liquors.

An equal quantity of the diſtilled oil of cloves or turpentine, and of Glauber's ſpirit of nitre, made as here deſcribed, are put together in a glaſs veſſel, and the mixture immediately takes fire and burns away.

RECREATION CV. p. 173

Artificial lightning.

Powder of reſin is put in a tin tube that has holes on one ſide, by which the powder is ſhook over the flame of a torch, when it produces a coruſcation that ſtrongly reſembles lightning.

RECREATION CVI. p. 173

Artificial thunder.

An ounce of oil of vitriol and two drams of iron filings are ſhook in a ſtrong bottle, and when a lighted candle is brought near the mouth of the bottle, an inflammation and a loud noiſe preſently enſue. A ſimilar exploſion produced by putting a certain quantity of the mixture of three parts of nitre, two of ſalt of tartar, and two of ſulphur, in an iron ſhovel over a coal fire.

RECREATION CVII p. 175

The predicted earthquake and volcano.

Equal quantities of iron filings and ſulphur are ground together: about fifty pounds of this powder is wrought up with water into a ſtiff paſte, and buried a foot under the earth. In about eight hours the ground will heave, emit ſulphureous ſteams, and at laſt, burſting into flames, form a true volcano.

RECREATION CV II. p. 176

To imitate a jet de feu, column, globe, or pyramid of fire.

In a black or deep blue paper are made a number of cuts with the end of a penknife, and holes with a piercer, that all run in ſtraight lines, as in plate X. Fig. 1. and 2: behind the paper is placed a ſtrong light, by which the figures appear as bright illuminations. To give theſe pieces motion, they muſt be placed on a wheel of thin wire, adapted to their figures, as that of Fig. 7, to the pieces 5 and 6; to theſe wheels any degree of velocity may be given. To repreſent pieces that flow from the circumference to the center, and at the ſame time others that flow from the center to the circumference, as in Fig. 9, a double ſpiral wheel, as Fig. 10, muſt be placed behind the other. When theſe pieces are of a ſmall ſize, they ſhould be placed in a box, that no light may appear, but what comes through the paper.

RECREATION CIX. p. 179

To repreſent caſcades of fire.

The paper to repreſent a caſcade is wound upon a roller, as Pl. XI. Fig. 3, and as the handle is turned, and the paper gradually deſcends, it repreſents a caſcade of fire. A caſcade may be alſo repreſented by a ſpiral, as in Fig. 4.

RECREATION CX. p. 180

Imitative illuminations.

Theſe illuminations differ from the preceding, in having figures of architecture, &c. drawn on the four parts of the

the paper, and thoſe parts only where the lamps are to appear, cut, or pierced. They are placed in a box, with a very ſtrong light behind; and a faint light before them, to make the drawing on the front of the paper viſible. The light of all theſe illuminations ſhould be of different colours, according to the pieces they are to repreſent, and which is to be effected by paſting a very thin paper, tinged with a particular colour, over the parts cut out.

APPENDIX.

RECREATION CXI. p. 183

Chymical tranſcolourations.

Antimony and mercury, by different preparations, produce almoſt all the colours of nature. A gold colour is made by mixing a limpid liquor with a grey powder, and then changed to the colour of milk by being poured into a clean glaſs, p. 184. An almoſt limpid liquor turned blue, and made pellucid. Method of producing various blues and greens, p. 184.

RECREATION CXII. p. 184

A colourleſs liquor is made black, by pouring it into a clean glaſs.

An infuſion of white galls is poured into a glaſs dipped into a ſolution of vitriol.

RECREATION CXIII. p. 184

A pellucid liquor is turned black, by adding to it a white powder.

The ſame done by a pellucid drop, or by the addition of yellow or red powder, or by a drop of gold coloured liquor, p. 185.—Method of making any of theſe black liquors pellucid again, p. 185, and then again black, &c.

RECREATION CXIV. p. 186

Different colours are produced by pouring a limpid liquor into a clean glaſs.

A ſolution of mercury or ſilver, in ſpirit of nitre, is poured into a glaſs dipped in ſpirit of ſea ſalt.

RECREATION CXV. p. 186

The colour that appears and diſappears by the influence of the air.

A blue tincture made of copper filings diſſolved in volatile ſpirit, diſappears when the bottle is ſtopped, but when it is unſtopped, the colour preſently returns.

SYMPATHETIC INKS. p. 186
These inks are of five sorts; the first of which are those that are invisible till exposed to the fumes of another liquor. Different methods of making these inks, p. 187. Method of preparing the vivifying liquor to make this ink apparent.

RECREATION CXVI. p. 189
The book of fate.
On seventy or eighty papers questions are wrote, and under them answers in these sympathetic inks. Several of these papers are chose by different persons, who put them in a book that has the same number of leaves, and on which the same questions are wrote. In the cover of this book is concealed a double paper, dipped in the vivifying liquor, and the book is closed; when the vapour of the liquor, penetrating the leaves, makes the answers on the papers become visible.

RECREATION CXVII. p. 190
The marvellous portrait.
At the bottom of a box (Plate XXXII. Fig. 5.) is placed a paper dipped in the vivifying liquor, and over it is put a pasteboard. Several papers on which figures are drawn with the sympathetic ink, are given to a person, and he making choice of one of them, you tell him it shall show him the portrait, and present the employment of an absent friend: then putting the paper in the box, and pressing it down by a board over it, after a few moments you take it out, and shew him a figure in the employment you intended.

RECREATION CXVIII. p. 192
The artificial hand.
A hand and arm of wood, constructed mechanically, are placed on a pedestal, covered with green cloth (Pl. XXXII. Fig. 6.) Between the thumb and fore-fingers, which are moveable, is placed a pen, and under that part of the cloth is put a paper dipped in the vivifying liquor. Several cards, on which questions are wrote, are given to a person, and he chooling one of them, you place a paper, on which the answer is wrote in the sympathetic ink, under the pen, and giving the arm a motion, by means of an assistant in an adjoining room, to the partition of which the arm joins, by the time the pen has passed over the paper the answer will be visible.

Sympathetic

Sympathetic inks of the ſecond claſs, which are thoſe that become viſible by being expoſed to the air. Inks of this kind made by the diſſolution of ſilver and other metals, p. 192.

RECREATION CXIX. p. 193
The writing againſt the wall.
A queſtion is wrote with common ink, and under it the anſwer in this ſympathetic ink. This paper being placed againſt a wall, the anſwer will be viſible after twenty-four hours.

RECREATION CXX. p. 194
The taliſman.
This taliſman conſiſts of a triangular metal box, (Pl. XXXII. Fig. 7.) in the top of which is concealed a heated plate of iron. A paper on which a queſtion is wrote in common ink, and an anſwer in that ſort of ſympathetic ink which does not appear till it is heated, is put in the box, and after a few moments the anſwer appears; each word of which is of a different colour.

RECREATION CXXI. p. 195
The ſibyls.
On the top of a hollow pedeſtal (Pl. XXXIII. Fig. 1.) is a dial, that has nineteen diviſions, in twelve of which are drawn the ſigns of the zodiac, and on the others the ſeven planets. To this dial is fixed an index, that is moved by a pulley underneath: this pulley communicates with two rollers in a box at the end of the pedeſtal, and on theſe rollers are wound a paper, on which is wrote the names of the ſeven ſibyls, one of which appears at an opening in the front of the box. On ſeven cards queſtions are wrote, and the ſigns of the planets drawn, and on the ſeven leaves of a book are wrote, in the ſympathetic ink that does not appear till heated, the names of the ſibyls, and in each leaf, on pieces of paper, different anſwers to each queſtion on the cards. A perſon chooſes one of the cards, and conceals the reſt; then ſets the index to the ſame planet on the circle as on his card, and covers the circle. He next opens the door in the front of the box, and tells you the name of the ſibyl. You then take out the papers in that leaf of your book where the name of that ſibyl is wrote, and the perſon chooſing one of them, puts it into the taliſman, and in a few moments it ſhows the anſwer.

RECREATION CXXII. p. 197

The magic urn.

You draw on a paper the figure of a flower, with that ink which reſembles it in colour, and does not appear till heated. You then burn a flower of that ſort on a chafing-diſh of coals, and ſtrewing ſome of the aſhes over the paper, you put it in an urn, (Pl. XXXIII. Fig. 5.) in which a ſmall heated cylinder is concealed, and taking it out preſently after, you ſhow the figure of the flower on the paper.

Methods of making yellow, red, green, and violet ſympathetic inks of the ſecond claſs, that is, ſuch as are not viſible, till another liquor is paſſed lightly over them, p. 198 —Preparation of the liquor to make theſe inks viſible, p. 199.

RECREATION CXXIII. p. 199

The revivified bouquets.

A bouquet is made of artificial flowers, each of which is put in one of theſe ſympathetic inks. The bouquet is then dipped in the vivifying liquor, when each of the flowers preſently appear of its natural colour.

RECREATION CXXIV. p. 199

The tranſcolourated writing.

You write ſeveral words on a paper with the violet ink, and aſk a perſon whether he will have them appear yellow, green or red. You then take a ſponge that has three diſtinct ſides, each of which is wetted with one of thoſe three ſympathetic inks, and draw one of the ſides of the ſponge over the writing, according to the colour required.

Sympathetic inks of the third claſs, that is, ſuch as become viſible by having a fine powder ſtrewed over them, p. 200.

RECREATION CXXV. p. 200

Magical vegetation.

A leaf or flower being drawn with this ink, you burn a ſimilar leaf or flower, and ſtrew its aſhes on the drawing, when the figure becomes immediately viſible.

Sympathetic inks of the fourth claſs, which are ſuch as become viſible by being expoſed to the fire, p. 200.

RECREATION CXXVI. p. 201

The tranſmutable cards.

Over an ace of hearts draw, with this ſympathetic ink, a ſpade and four other ſpades on each ſide of it. Let a perſon

ſon draw this card, and another perſon the nine of ſpades, and let the laſt perſon burn his card. You give the aſhes to him who drew the heart, that he may put them with that card, in a metal box, over a chafing-diſh, for a ſhort time, and when he takes it out, he finds it turned to the nine of ſpades.

RECREATION CXXVII. p. 201

The convertible cards.

You write on a card the word *law*, with this ink, and hold it before the fire till it is viſible. You then add to and alter the letters of that word, with this ink, ſo as to make it *old woman*, and leave the alteration inviſible. A perſon draws this card and writes his name on it, which you hold to the fire to dry, when the alteration you made becomes viſible.

RECREATION CXXVIII. p. 202

The oracular letters.

Several queſtions are wrote on different papers, in this ink, and held before the fire. The anſwers are wrote and left inviſible. Theſe papers are folded up in form of letters, with the anſwers under the part where they are ſealed, and the heat of the wax makes them viſible. A ſimilar experiment with a card encloſed in a letter.

Method of making the ſympathetic ink of the fifth claſs, which does not appear till heated, and diſappears when cold, p. 203.

RECREATION CXXIX. p. 204

The incomprehenſible writing.

The names of two cards are wrote with this ink, at the two ends of a paper, (Pl. XXX. Fig. 6.) Two perſons draw the ſame cards privately, and you propoſe to make the names of thoſe cards appear on the paper, without knowing what they are. You then put the paper in a metal box, Fig. 4, under one end of whoſe cover is a heated plate of metal, and the names become alternately viſible.

RECREATION CXXX. p. 205

Winter changed to ſpring.

In a print that repreſents winter, the trees, plants, &c. are traced over with this ink, and when the print is ſet in the ſun they become perfectly green. If it be placed again in the cold, winter again appears: and thus the two ſeaſons may be changed, alternately, a great number of times.

Methods

Methods of making ſympathetic inks, that appear by being wetted with water, p. 205.

RECREATION CXXXI. p. 206
The oracular mirror.

A mirror is moveable in a frame; (Pl. XXXIII. Fig. 7.) on one ſide of this mirror is wrote with Spaniſh chalk, the word *yes*: on the other ſide is wrote *no*: theſe words are wiped off, but when breathed on become viſible. A perſon aſking a queſtion, you put your mouth to the mirror, as if to whiſper to it, and the word *yes* or *no* appears immediately.

RECREATION CXXXII. p. 207
The tree of Diana.

This tree is made by a globule of the amalgam of ſilver with mercury, put in a diſſolution of ſilver filings and mercury in aqua fortis. From this globule ariſe branches, that, by ſpreading, form a ſhrub or buſhy tree, of a ſilver hue. Another method of producing this tree, p. 207.

RECREATIONS OF ADDRESS AND DEXTERITY.

Recreations with the cards—Method of making the paſs, p. 208.

RECREATION CXXXIII. p. 209
The card of divination.

You make ſeveral perſons, who do not ſtand very near each other, draw the long card; and each perſon ſhuffles the pack. You then lay down ſeveral cards, among which is the long card, and aſk each perſon if he ſee his card. You ſhuffle the pack, and cutting at the long card, go up to one of the parties, and ſhow him his card; and repeat the ſame operation for all the others. Method of performing this Recreation by making the paſs, p. 210.

RECREATION CXXXIV. p. 210
The four confederate cards.

You ſhow a perſon four cards that he may think on one of them: then dextrouſly place two of them at top and two at bottom. You take ſeveral cards from the bottom, and aſk the perſon if his card be among them: if not you paſs the two cards from the top to the bottom, and ſhow one of them; and if that be not his card, you bid him draw it from the bottom. If his card be among thoſe you firſt drew, you ſeparate them dextrouſly from the reſt,

reſt, place them at the bottom, and then do as before directed.

RECREATION CXXXV. p. 211
The numerical card.
The ſixteenth card, in a piquet pack, is a long card. You take ſeveral from the top, and a perſon thinks of one of them. You make the paſs, and he telling you what number from the top his card was at, you count from that number to 16, and draw aſide the 17th, which is the card. You then aſk how many more you ſhall draw before the card appear, which being done you throw down the card.

RECREATION CXXXVI. p. 211
Divination by the ſword.
Place a card drawn under the long card, and then bring it to the top. Throw the pack on the ground, and obſerve where the top card falls. A handkerchief being bound over your eyes, in ſuch manner that you can ſee the ground, you touch ſeveral cards with a ſword, and at laſt fix it in the top card.

RECREATION CXXXVII. p. 212
The cards thought on per force.
Several cards are ſpread before a perſon, in ſuch manner that only one is completely viſible, and you obſerve, carefully, whether the perſon fix his eye on that card: if not, you make him draw a card, and perform ſome other Recreation.

RECREATION CXXXVIII. p. 212
The tranſmutable cards.
There are two cards of the ſame ſort, one of which is put at top, and the other next the bottom card. You ſhow a perſon the bottom card, and convey it dextrouſly away; then drawing off the ſuppoſed bottom card, you direct the perſon to put it under his hand. You next ſhuffle the pack, and bringing the top card to the bottom, you ſhow it to another perſon, and convey it privately away; then drawing off the next card you direct the laſt perſon to put it under his hand, and command the cards under the two perſons hands to change places, which they will appear to do.

RECREATION CXXXIX. p. 213
The three magical parties.

A perſon

A perſon draws the long card, and puts it in any part of the pack. You make the paſs, and bring it to the top: then divide the pack into three heaps, and aſk him in which heap his card ſhall be, and at what number it ſhall appear. You place the heap he names over that at the top where the card is, and after telling down the number of cards named, you make the paſs, bring the card to the top, and turn it up.

RECREATION CXL. p. 213

The inverted cards.

One end of all the cards of a pack are cut a ſmall matter narrower than the other. A perſon draws a card, and when he puts it in again you offer the other end of the pack: the cards are then ſhuffled, and as you turn them up, one by one, you diſtinguiſh, by the touch, the card he drew.

RECREATION CXLI. p. 214

The card diſcovered by the touch or ſmell.

A perſon draws the long card, puts it in again, and ſhuffles the cards. You pretend to feel the figures on the cards, or ſmell to them, and when you come to the long card you turn it up.

RECREATION CXLII. p. 214

The incomprehenſible tranſpoſition.

A card of the ſame ſort as the long card is put in an egg: you make a perſon draw the long card, and while he is breaking the egg, you conceal that card. This Recreation diverſified by offering ſeveral eggs that each contain the ſame card; and by a confederate, who knows the egg in which the card is put.

RECREATION CXLIII. p. 215

The card in the pocket-book.

This is performed by the aid of a confederate, who knows the card you have taken from the pack, and concealed in your pocket-book.

RECREATION CXLIV. p. 216

To tell the card that a perſon has only once touched with his finger.

You agree with your confederate on certain ſigns, by which to expreſs the ſuit and particular card; and you fix on a perſon to touch the card who ſtands near your confederate.

RECREATION

RECREATION CXLV. p. 216
To name ſeveral cards that two perſons have drawn from the pack.
You divide a piquet pack into two parts by a long card, and ſo diſpoſe the cards of each part that you can eaſily recollect them. You let a perſon draw two or more cards from the firſt part, and put them into the ſecond; and in like manner, another perſon draws from the ſecond part and puts them into the firſt, and by ſpreading the cards on the table, you eaſily diſtinguiſh which cards were drawn.

RECREATION CXLVI. p. 217
The two convertible cards.
On the ace of ſpades a heart is ſlightly paſted, and on the ace of hearts a ſpade You lay theſe two cards on the ground, and at the ſame time ſlipping off the figures paſted on them, and deſire two perſons to put each of them his foot on one of the cards, and you then command the two cards to change places; which they appear to do. Method of performing a ſimilar experiment with a ſingle card. p. 217.

RECREATION CXLVII. p. 217
The fifteen thouſand lives.
You take two cards like Plate XXXIV. Fig. 3. with an ace and five of diamonds; and by placing theſe cards in different poſitions, you make them appear to be either 3 or 15.

RECREATION CXLVIII. p. 218
The card diſcovered under the handkerchief.
A perſon draws a card and puts it in the middle of the pack: you make the paſs, and bring it to the top. Then throwing a handkerchief over the pack, you take off the top card, ſeeming at the ſame time to ſearch among the cards.

RECREATION CXLIX. p. 219
To change the card that ſeveral perſons have drawn from the pack.
You make the paſs, bring the top card to the middle, and let a perſon draw it: then make the paſs again, and bring it to the middle, and let a ſecond perſon draw it; and ſo

so for three or four more. You after ſhow the card to the ſeveral parties, ſeparately, and they all acknowledge it to be the card they drew.

RECREATION CL. p. 219

The four inſeparable kings.

The four kings and two other cards are put at the bottom: one of the kings is drawn and put at the top; then the two other cards are drawn and put in different parts, and when the cards are cut, all the kings will be together in the middle.

RECREATION CLI. p. 220

To tell the number of cards by their weight.

There are two long cards, whoſe number from the top you know, and by cutting at theſe cards you tell the number over them.

RECREATION CLII. p. 220

To diſcover the card that is drawn by the throw of a die.

The pack conſiſts of only ſix ſorts of cards repeated ſix times, and at the bottom of each parcel is a long card. A perſon draws one of theſe cards and puts it into the ſame parcel again. You cut the pack, by the long cards, into ſix heaps, and giving the perſon a die, tell him his card ſhall be in that heap which anſwers to the number he throws on the die.

RECREATION CLIII. p. 221

To ſeparate the two colours of a pack of cards by one cut.

The cards are prepared by cutting thoſe of one colour ſomething narrower than the others, as in a former Recreation, and then you ſeparate the two colours by one motion of your hands.

RECREATION CLIV. p. 221

The metamorphoſed cards.

Under a wide card in the middle of the pack is placed two particular cards, and two others of the ſame ſort at the top: and between them two cards on which figures are painted. You open the pack at the wide card, and let a perſon draw one of the two cards and replace it: you then dextrouſly bring one of the painted cards at top to the middle, and ſhew him the change: you perform in the like manner with another perſon and two other cards.

RE-

RECREATION CLV. p. 223
The cards in the opera glaſs.
At the end of an opera glaſs is a ſmall card, but which appears there of the common ſize: this card has figures on both ſides, either of which is viſible by turning the glaſs differently. You make a perſon draw one of thoſe cards from the pack, and then ſhow it him in the glaſs.

RECREATION CLVI. p. 223
The magic ring.
Under a large tranſparent ſtone in a ring (Plate XXXIV, Fig. 9.) is the figure of a ſmall card and over it a piece of ſilk that may be drawn aſide, by turning the ſtone round. A perſon draws a ſimilar card from the pack, and burns it. You rub the ſtone with the aſhes, and turning it about, ſhew the perſon the card he burnt.

RECREATION CLVII. p. 224
The card in the mirror.
A mirror is moveable in its frame, which is of the width of a card (Plate XXXIV. Fig. 10.) A part of the quickſilver is ſcraped off the mirror, and a card fixed over that part, which is to be behind the frame. This mirror moves in a groove, and there are two ſtrings that go from the back of it, through the partition of the room. You make a perſon draw the ſame ſort of card as that in the mirror, and put it in the middle of the pack: You make the paſs, and bring it to the bottom; then tell him to look in the mirror for his card, and while the confederate is bringing it forward you ſecrete the card he drew.

RECREATION CLVIII. p. 225
The marvellous vaſe.
A vaſe that is placed on a bracket (Plate XXXIV. Fig. 11.) has five diviſions, in three of which a ſingle card is placed, and in another a pack of cards. There is a ſtring that goes through the three ſmall diviſions down the bracket, and through the partition. Three perſons draw from a pack three cards of the ſame ſort with thoſe in the vaſe, and putting them in again, ſhuffle the pack, which you put in the fifth diviſion. Your aſſiſtant then makes the three cards riſe gently out of the vaſe, by drawing the ſtring. You take out the other pack, that you had previouſly placed in the fourth diviſion, and ſhow that the three cards are gone from it.

RECREATION CLIX. p. 226
The divinating perſpective glaſs.
A ſmall table of numbers is placed at the end of a perſpective glaſs. You give a perſon a pack of twenty ſeven cards, that he may think on one of them. You then lay the cards down, ſingly, in three heaps; aſk the perſon in which heap his card is; and at what number it ſhall appear. Then look at that heap through the glaſs, and according to the number that ſtands in the perſpective againſt that he mentioned, you put the heap either at top, in the middle, or at bottom: this operation you perform three times, and then telling the cards down, one by one, the card he fixed on will be at the number he named.

RECREATION CLX. p. 228
The burnt writing reſtored.
The inſide of the cover of a memorandum book is rubbed over with ſoot mixed with brown ſoap; under this cover you place a piece of paper, and give a perſon another paper, which he lays on the outſide of the book, and writes what he thinks proper, with a pencil you give him, and that will not mark without preſſing hard on it: therefore as he writes on the cover, the ſame letters will be impreſſed on the paper under it. You direct the perſon to burn what he has wrote, without ſhowing it: and going into another room to feteh a box, you take the paper from the memorandum-book, and put it in one ſide of the box. You return to the room, put a blank paper in the other ſide of the box, and preſently after turning it dextrouſly over, you take out the paper on which the impreſſion is made, which the perſon will aeknowledge to be his writing.

RECREATION CLXI. p. 229
The opaque box rendered tranſparent.
A perſon writes what he thinks proper on a ſlip of paper, the memorandum-book deſcribed in the laſt Recreation being placed under it, and puts the paper in a box which he keeps. You put the memorandum-book in the preſs, mentioned in the 121ſt Reereation, and your confederate takes it out, and puts it at the bottom of a perſpective, which you take out, and holding it over the box, ſee what is wrote on the paper, pretending at the ſame time to ſee through the top of the box. A ſimilar experiment with

with a counter that is taken out of a bag, and another counter of the ſame ſort put at the bottom of a perſpective, p. 229.

RECREATION CLXII. p. 230
The tranſpoſable pieces.

Two guineas and two ſhillings are ground to half their common thickneſs, and then one of each ſort joined together. One of theſe double pieces is placed in one hand, with the guinea upward, and the other in the other hand with the ſhilling upward: then by cloſing your hands you turn the pieces over, when the ſhilling and guinea appear to have changed places.

RECREATION CLXIII. p. 230
The geometric money.

A piece of paſteboard in form of a parallelogram, (ſee the Fig. p. 230.) is divided into thirty equal parts, in each of which is drawn the figure of a piece of money. This parallelogram is cut into four parts, and thoſe parts, when formed into two figures, as in p. 231, contain the figures of thirty-two pieces of money.

RECREATION CLXIV. p. 231
The penetrative guinea.

In a tin box, of the ſize of a ſnuff box, there are eight more which go into each other; they all ſhut with a hinge and the laſt is locked. Theſe boxes are placed in a drawer, and open. You deſire a perſon to lend you a new guinea, and mark it; this guinea you ſlip into the leaſt box and cloſe them all at once in taking them out of the drawer; then having another new guinea in your hand, and which is ſuppoſed to be the ſame, you pretend to make it paſs through the box, and convey it away. You then give the boxes to any one, and he opens them all to the laſt, of which you give him the key, and on opening that box he finds the guinea he had marked. This Recreation improved by ſlipping the key into a ſtranger's ſnuff-box, or by a confederate, p. 232.

RECREATION CLXV. p. 232
The reſuſcitated flower.

There is a double tin mortar, and between its two bottoms is a vacuity. At the ſide of this mortar is a ſpring, by which the bottom is turned round. Having placed a flower between the two bottoms, you take another of the ſame

fort, and pulling it to pieces, pound it in a mortar, which you then hold over a lamp, that the flower may be reflored; and at the same time pressing the spring with your finger, the bruised parts descend and the whole flower turns up, which you take out and present to the company.

AN ARTIFICIAL MEMORY.

Methods of remembering numbers or dates by the vowels and consonants, p. 204.—Words to be remembered by joining their initials to vowels and consonants, and forming these combinations into verse, p. 204.

THE END.

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OUNG J


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